Fricke and Sloane

Tests of a High Speed Ideal Engine with Superheated Steam

Mechanical Engineering

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TESTS OF A HIGH SPEED IDEAL ENGINE WITH SUPERHEATED STEAM

BY

Herman Henry Fricke
Robert Hugh Sloane

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE
IN MECHANICAL ENGINEERING

IN THE
COLLEGE OF ENGINEERING
OF THE
UNIVERSITY OF ILLINOIS
PRESENTED JUNE, 1907

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June 1, 1907

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

HERMAN HENRY FRICKE and ROBERT HUGH SLOANE

ENTITLED TESTS OF A HIGH-SPEED IDEAL ENGINE

WITH SUPERHEATED STEAM

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Mechanical Engineering

L. P. Breckenridge

HEAD OF DEPARTMENT OF Mechanical Engineering

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TESTS OF HIGH SPEED IDEAL ENGINE WITH SUPERHEATED STEAM

I INTRODUCTION:

As this test deals with the subject of superheate d steam it may be well to make a few remarks as to its early uses and present applications.

Superheated steam was known as early as 1828 when Gregor, a Cornish engineer, built flues around the steam pipes and cylinder of his pumping engine at the Bonner Downs Mine, thereby raising the duty of the engines 50 per cent. Although this was followed by methods, adapted chiefly in France, for superheating steam in a somewhat similiar manner, it was not until 1855 that the present system was developed by a German engineer, Hirn, and its practical utilization accomplished by Wethered, an American engineer. Although more or less used in Europe, practically nothing had been done in this country as late as 1896.

A great many things have been done since that time, nevertheless, its application has been slow and tedious, due, not to a lack of theoretical knowledge, butto mechanical difficulties such as, the burning out of packing, destruction of lubri-

cants, excessive expansion of valves and cylinders, etc. All these difficulties have been, however, gradually overcome and today there are few steam installations in which the question of using superheating apparatus is not at least considered.

II OBJECT OF TEST:

The object of this test was to determine the water rates of the 60 H.P. High Speed Ideal Engine, in he Mechanical Engineering Laboratory of the University of Illinois, running non-condensing, with superheated steam, at the following loads; quarter, half, three-quarter, full, and one and one-quarter.

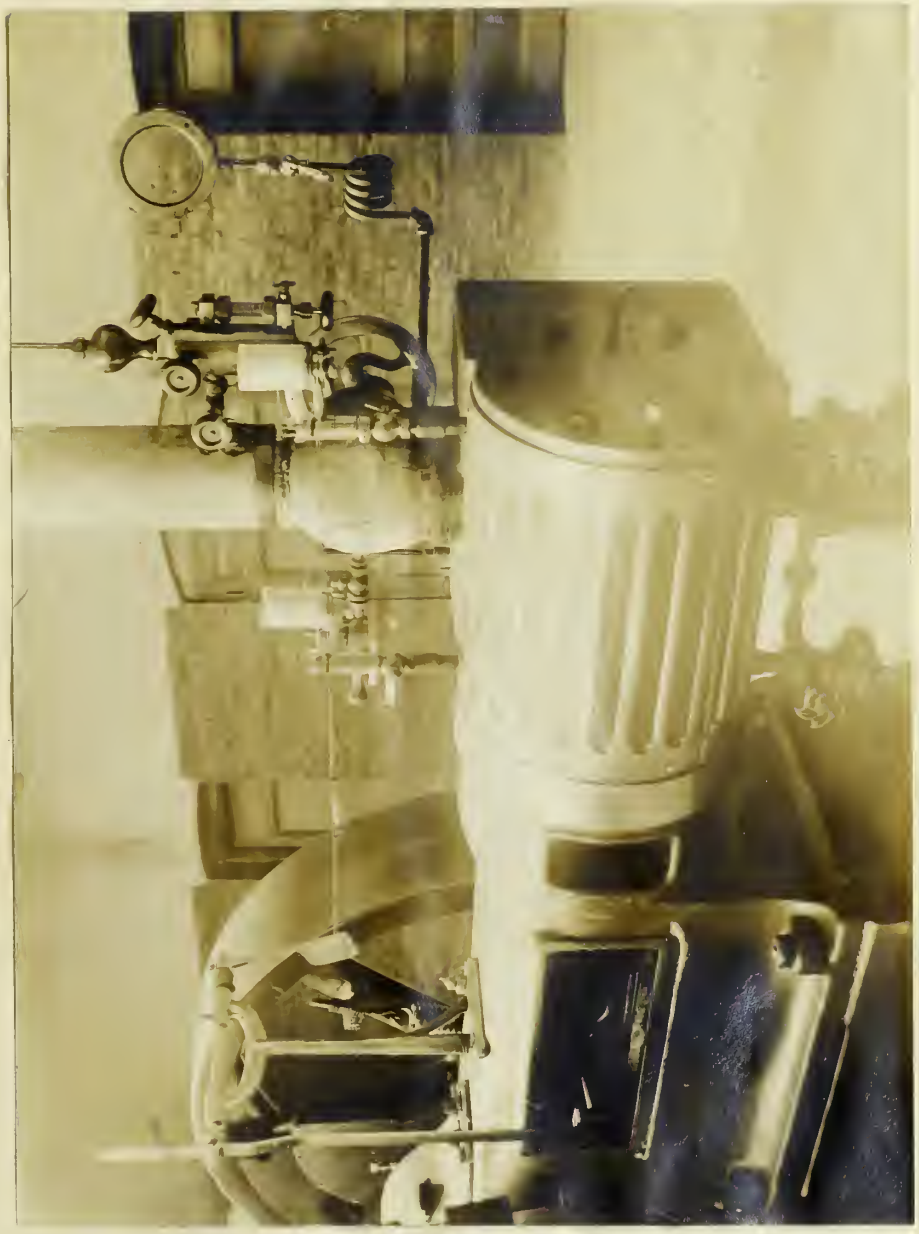
III DESCRIPTION OF APPARATUS:

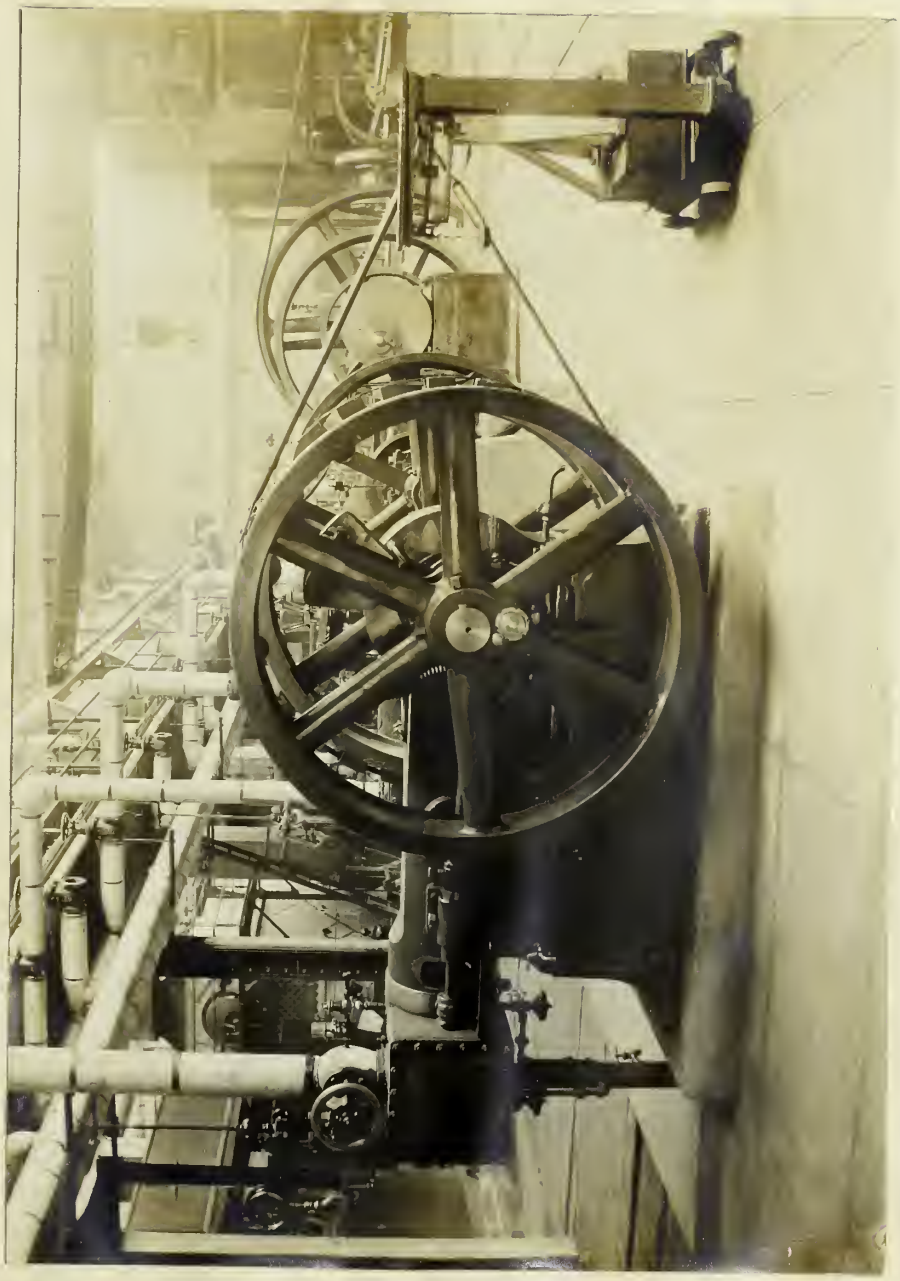
(1) Engine

The engine is a 10"x10", Horizontal, High Speed, Automatic cutoff, Slide Valve Engine, manufactured by A.L.Ide & Sons, Springfield, Illinois. Photographs of the engine are shown on pages 3, 4, and 8.

(2) Auxiliary Apparatus

The steam was superheated in a Foster, independently fired, suprheater manufactured by the Power Specialty Co., New York. This superheater has a capacity of superheating 4500





pounds of steam per hour 200 degrees F.

The condenser used was a Wheeler Surface Condenser, manufactured by the Wheeler Condenser & Engineering Co., New York. There are 225 square feet of condensing surface. The cooling water, circulated by a steam pump on the condenser, was drawn from the Bone Yard.

(3) Instruments and Their Calibration

Instruments used in the test were; pressure gages, thermometers, platform scales, indicators, a calorimeter, and a speed counter.

The gages were tested cold by means of a Crosby Fluid Pressure Scale. By using cylinder oil in a five-coiled syphon it was found that the gages remained perfectly cool throughout the tests, thus rendering the calibration of the gages while hot unnecessary.

The high temperature thermometers were calibrated with reference to a standard in the Physics Department.

The indicators used were of the Crosby make. The springs used in these indicators were calibrated by means of a Fluid Pressure Scale.

The platform scales were calibrated by the use of Standard weights in the laboratory.

IV Preliminaries to Tests.

The valve on the engine was set by the indicator method. In the setting of the valve, the engine was run on saturated steam.

Leakage tests were run on the condenser after several engine tests as follows:- The engine was shut down and the condenser kept in operation, the water condensed being weighed after equal intervals of time. In every case it was found that after operating a short time no water was pumped from the condensers, indicating that there was no leakage.

V Method of Conducting Test.

Having assumed that 500 degrees F. is the highest temperature that can be safely used with the type of valve on this engine, and that the higher the degree of superheat the more economical the steam consumption, it was decided to run all the tests at approximately this temperature in the steam chest. This, with the prevailing steam pressures gave a superheat of about 150 degrees.

Considerable time was given to bring the engine to a normal condition of running, so that all the engine parts were thoroughly heated and a constant degree of superheat could be maintained.

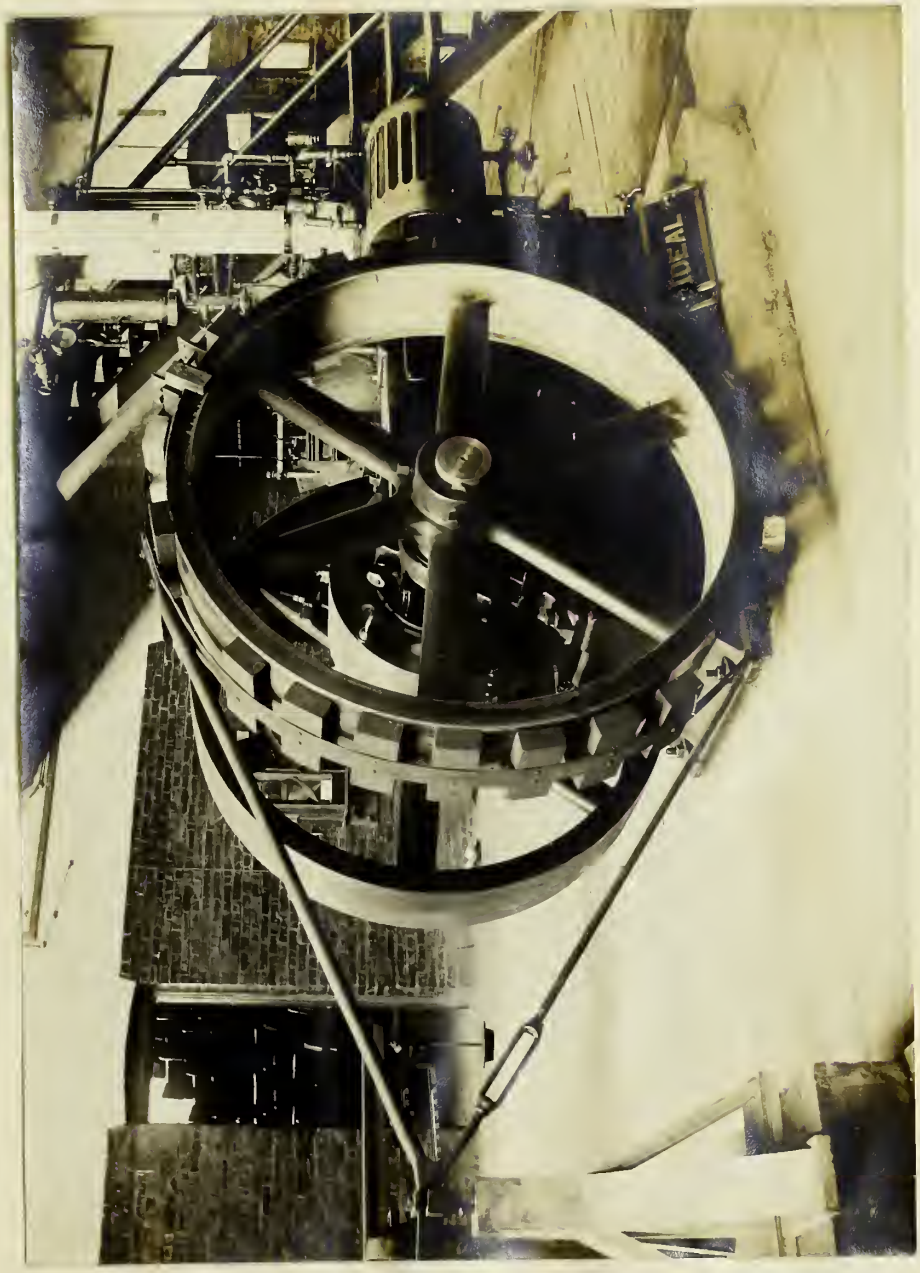
The power was absorbed by a Prony brake, the arrangement of which is shown in the photograph on page 8. The load was recorded on the platform scales shown in the photograph.

Two two-hour tests were run at each load for the purpose of comparison. Readings were taken at ten minute intervals as follows:- pressure and temperatures at the superheater, in the steam chest, and in the exhaust, the boiler pressure, or pressure of steam entering superheater, also being recorded; indicator cards were taken at both head and crank ends; the quantity of steam condensed in ten minutes recorded; R.P.M. of engine and weight on brake scales. The weight on the brake scales was kept constant for each test.

VI Discussion of Data.

All observed and calculated data are shown on the data sheets. There are five such sheets each sheet containing the data for the two tests at the same load. The tests were numbered with reference to the load rather than the order in which they were run. Thus, tests No.1 and No.2 are at quarter load; No.3 and No.4 at half load, etc.

All the observed data not correct, on account of instrumental errors determined by the calibration of the instruments, were corrected before being placed on the data sheets.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The superheat, as is shown by the data, was not kept exactly constant as was intended. This is due to the fact that it was found impossible to obtain a constant pressure and, although the temperature could be kept constant in the steam chest, the degree of superheat would vary with the pressure. The maximum variation, however, was only about 20 degrees F.

It may be noticed that the steam pressure in the steam chest is sometimes higher than the boiler pressure. This would be caused by the personal error of the recorder. The two readings were taken by different recorders and, as the smallest subdivisions on the gages were five pounds, there was a chance for difference in reading.

The mechanical effeciency in a few instances is seen to be more than 100 per cent. All of these cases occur, as will be noted, in the three-quarter load tests. As these tests were run in succession it is probable that the brake did not work properly, i.e., it tightened up on the wheel and then loosening up caused a sudden drop in the load. It is possible that some of the cards were taken just when this drop occured, making them much smaller than if taken at the proper load.

As the load on the brake was always recorded as constant this sudden drop would not be considered in calculating the B.H.P. This being the case, it can readily be seen how it is possible to have the B.H.P. larger than a corresponding I.H.P. and,

therefore, an efficiency of over 100 per cent.

VII Calculations.

The calculated data consists of (1) B.H.P., (2) I.H.P., (3) Mechanical Efficiency, (4) Thermal Efficiency, (5) Degree of Superheat at superheater, (6) Degree of Superheat at steam chest, (7) Degree of Superheat in exhaust, (8) Water Rate per B.H.P. hour and (9) Water Rate per I.H.P.hour.

The B.H.P. was calculated from the equation

$$B.H.P. = \frac{2\pi R.W.N}{33000}$$

Where R = length of brake arm in feet

W = net weight on brake scales

N = R.P.M. of engine

The I.H.P. was obtained for each end of cylinder from the equation

$$I.H.P. = \frac{P\ L\ A\ N}{33000}$$

Where P = mean effective pressure per square inch of piston area obtained from indicator cards. Sample graphs of cards shown on pages 12 to 16

L = Length of stroke in feet

A = net area of piston in square inches

N = R.P.M. of engine

The mechanical efficiency was obtained from the equation

$$\text{Eff.} = \frac{\text{B.H.P.}}{\text{I.H.P.}}$$

In determining the thermal efficiency the question arose as to which efficiency to use. It was finally decided to use the following ratio :-

$$\text{Thermal Eff.} = \frac{\text{Foot pounds work per H.P. hour}}{\text{Energy in steam used per I.H.P. hour}}$$

or placing this in the form of an equation,

$$\text{Thermal Eff.} = \frac{1{,}980{,}000}{778(H + 0.48T_s)W}$$

where W = pounds of steam per I.H.P.hour

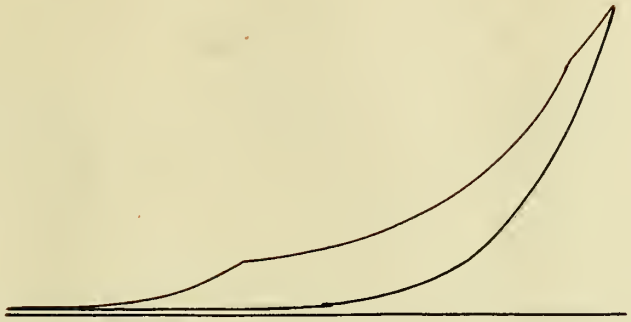
H = total heat of saturated steam

T_s = degrees of superheat

0.48 = specific heat of steam

The water rate per H.P. hour was obtained by dividing the weight of steam condensed in ten minutes by either the B.H.P. or I.H.P., according to the result desired, and then multiplying this quotient by "6".

The degree of superheat in all these cases was obtained by subtracting the temperature of saturated steam at the pressure recorded from the observed temperature of the steam.



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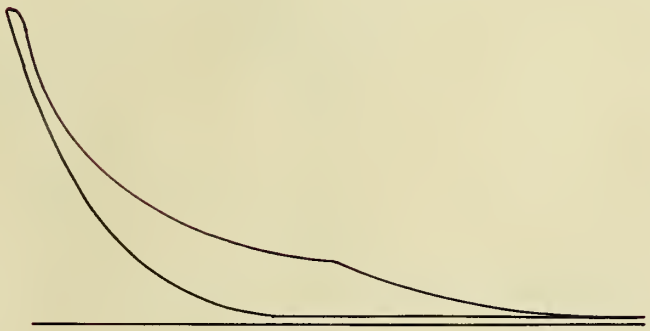

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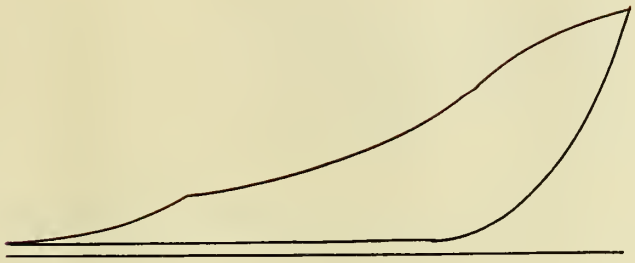
Sample Cards at Quarter Load



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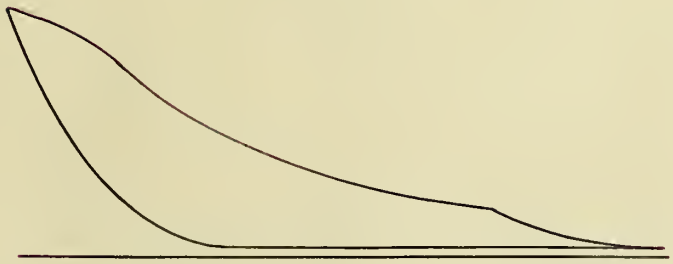

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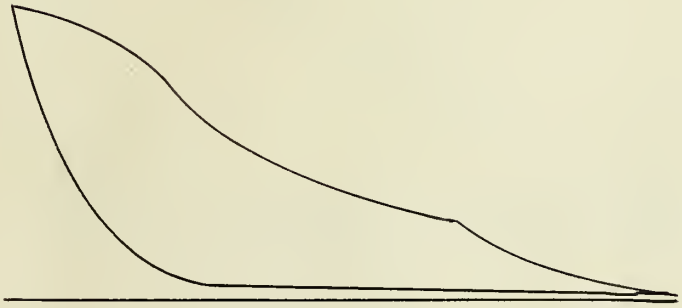
Sample Cards at Half Load

Crank End



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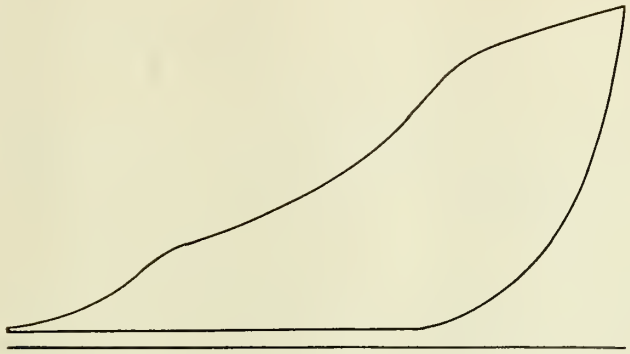
Sample Cards at Three-Quarter Load



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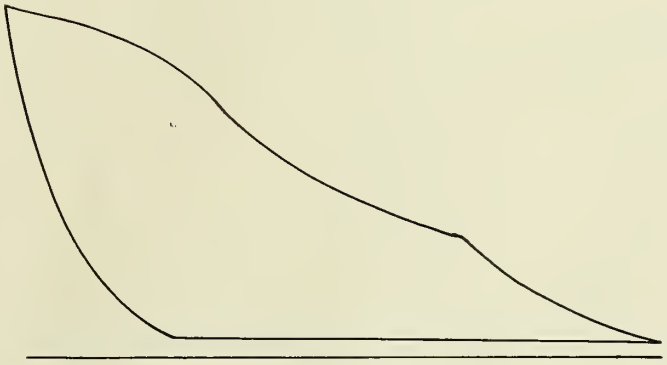

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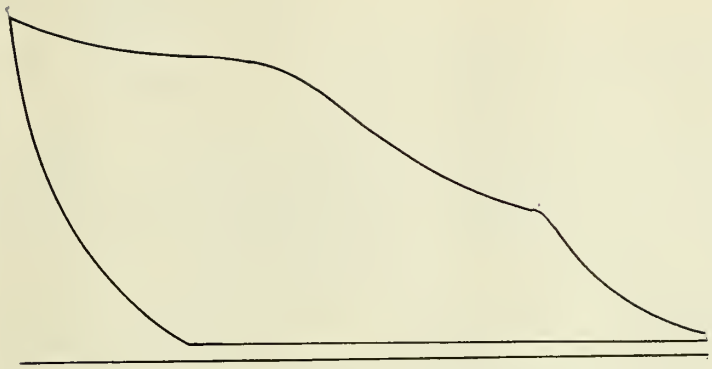
Sample Cards at Full Load



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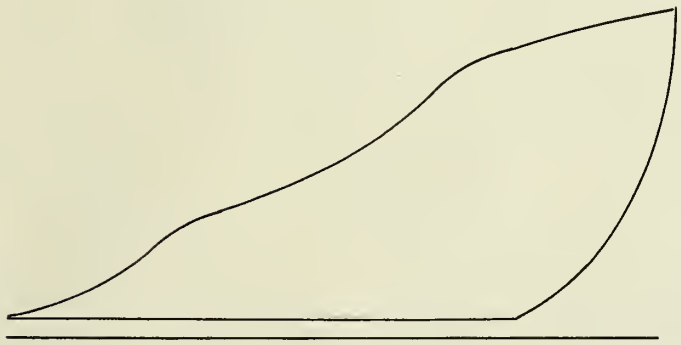


Crank End

Sample Cards at One and One-Quarter Load

VIII Curves and Graphical Logs.

In order to show graphically the relation between the various readings taken, a graphical log was plotted for one test at each load. These logs were constructed by taking time as abscissae and plotting as ordinates, (1) Boiler pressure, (2) Pressure in steam chest, (3) Pressure in exhaust, (4) Superheat in steam chest, (5) Superheat in exhaust, (6) R.P.M., (7) I.H.P., (8) B.H.P., (9) Mechanical Efficiency, (10) Thermal Efficiency, (11) Pounds of steam per B.H.P.hour, and (12) Pounds of steam per I.H.P. hour. These logs are shown on pages 27 to 31 inclusive.

Using the different loads as abscissae, curves were plotted showing the relation between the steam consumption per I.H.P. hour and B.H.P. hour, and the I.H.P. and B.H.P. developed. It may be noted thatthe points for the one and a quarter load do not lie on a smooth curve drawn through the other points. This is doubtless due to the fact that it was attempted to develope more power than the engine was capable of producing. Frequently the engine would slow down, and each time part of the load had to be taken off to allow the engine to return to its normal speed. This changing of the load makes the results for these tests somewhat doubtful. A better knowledge of the result can probably be obtained by referring to the curves on page 34.

A curve was plotted with loads as abscissae and pounds of steam flowing per hour as ordinates. From this curve can be obtained approximately the pounds of steam flowing per hour for any load and from this the probable water rate may be calculated. This curve is shown on page 33.

With loads as abscissae curves were plotted showing the relation between the loads and efficiencies both mechanical and thermal. These curves are shown on page 32.

IX Notes on Test.

Anticipating trouble in keeping the pressure gages cool, it was decided, as an experiment, to use a five-coil syphon filled with cylinder oil. This gave perfect satisfaction, for at all times throughout the tests, the gages remained cool.

For lubrication of valve and piston a good grade of cylinder oil was used and gave excellent results, for, upon examination after the series of tests had been run, the valve was found to be bright and smooth and showed not the slightest trace of cutting.

Little trouble was encountered from the burning out of the packing while the tests were being run, or when tests were run on successive days. When two or three days had elapsed between tests, however, it was found necessary to renew the

packing in the stuffing boxes. Judging from the results obtained it is probable that an engine could not be run more than thirty-six hours at this high temperature unless some special kind of packing were used.

The pipe line from the superheater to the engine, a plan of which is shown on page 20, was a 4" pipe covered with magnesia insulation. The total length of this pipe from the superheater to the engine is about 130 feet. The loss in superheat, due to radiation, amounted to approximately 100 degrees.

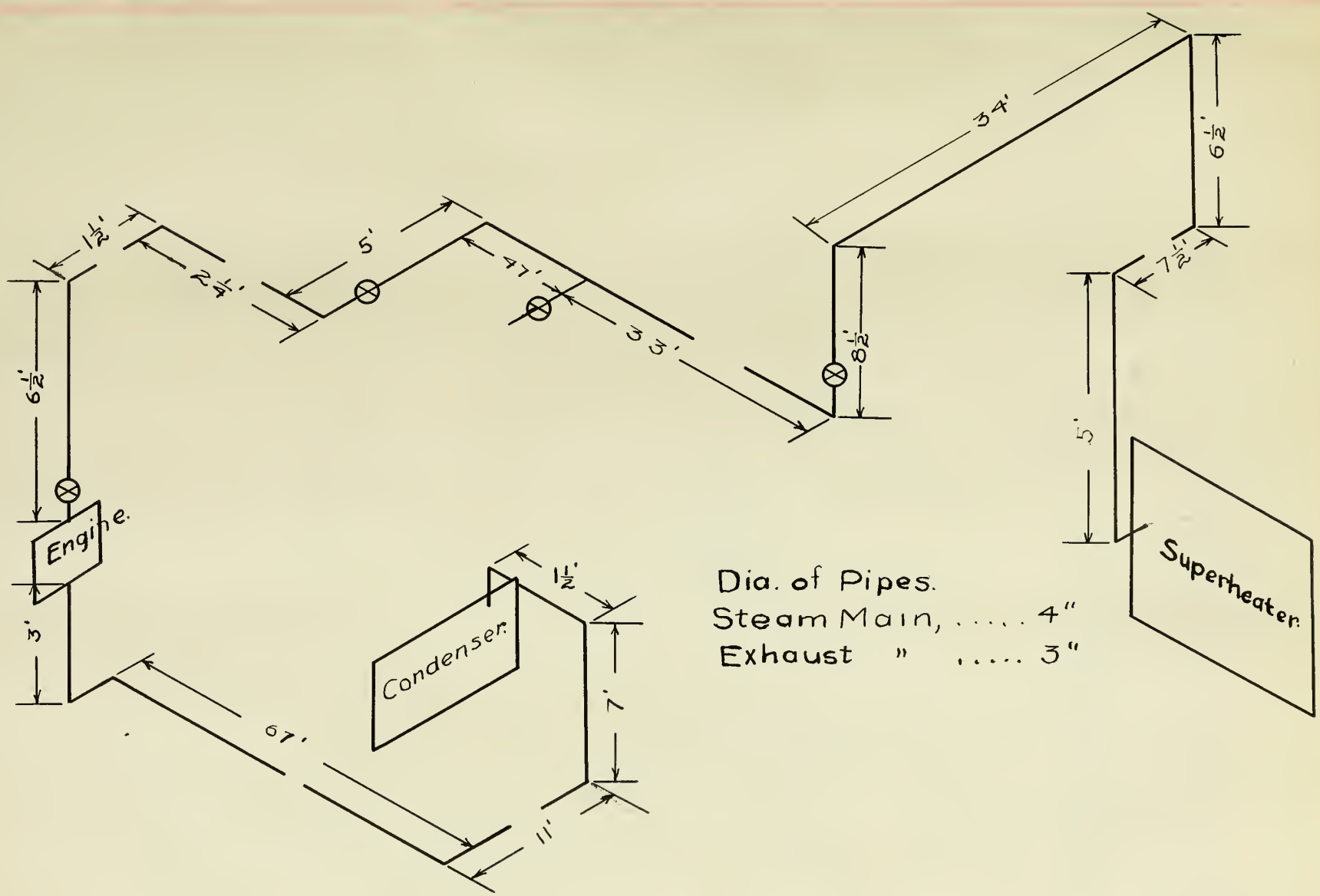
The exhaust from the engine was carried to the condenser, a distance of about ninety feet, through a 3" pipe line. The size of the exhaust line was probably too small for at the large loads, the back pressure was, in some cases, as high as ten pounds. The plan of the exhaust piping is shown on page 20.

X Conclusions.

There should be no difficulty in running an ordinary high speed slide valve engine with 150 degrees superheat at a steam pressure of 145 pounds gage.

Ordinary high grade cylinder oil can be used satisfactorily with superheat.

Where it is necessary to pipe the superheated steam any distance, the loss, due to radiation, is considerable.



PLAN OF PIPING.

For high degrees of superheat rubber packing cannot be used with any degree of satisfaction. If allowed to stand a few days after being subjected to this high temperature, it becomes dry and falls to pieces.

CONDITIONS,—
LOAD,— $\frac{1}{4}$
PRESSURE,— 113.5
DEGREE SUPERHEAT,— 164.5

THESIS
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No	Wt. on Scales Lbs.	B.H.P.	Mech. Effic. %	Therm. Effic. %	Lbs. Steam I.H.P. Hr	Lbs. Steam B.H.P. Hr	Remarks,—
1	50	15.25	65.4	0	0	0	
2	"	15.60	69.0	3.98	50.3	73.0	
3	"	15.50	72.8	3.7	53.8	74.0	
4	"	15.15	70.0	4.1	49.3	70.5	
5	"	15.15	63.3	4.35	46.1	73.0	
6	"	15.00	65.2	4.32	46.7	70.9	
7	"	15.15	64.0	4.37	44.1	69.0	
8	"	15.35	67.0	4.03	49.8	74.3	
9	"	15.15	67.3	4.03	50.4	75.0	
10	"	15.05	70.5	3.85	52.5	74.5	
11	"	15.10	79.5	3.55	57.0	71.7	
12	"	15.15	77.1	3.82	52.8	68.5	
13	"	15.20	67.0	4.25	47.5	70.8	
To	650	197.65	898.1	48.35	610.3	865.2	
Av	50	15.2	69.1	4.06	50.8	72.	

LOAD,— $\frac{1}{4}$
PRESSURE,— 130.2
DEGREE SUPERHEAT,— 134.9

1	50	15.50	76.2	0	0	0	
2	"	15.35	66.1	4.12	49.3	74.5	
3	"	15.35	72.0	3.98	51.3	71.2	
4	"	15.25	71.5	3.80	53.6	75.0	
5	"	15.20	71.0	3.76	54.1	76.2	
6	"	15.25	70.5	3.98	51.2	72.5	
7	"	15.20	71.1	3.82	52.8	72.8	
8	"	15.20	72.0	4.07	49.6	69.0	
9	"	15.20	79.5	3.36	60.5	76.1	
10	"	15.30	74.0	3.64	55.7	75.2	
11	"	15.20	74.2	3.80	53.3	71.8	
12	"	15.00	76.6	3.47	58.2	76.0	
13	"	15.15	73.6	3.74	54.3	73.5	
To	650	198.15	948.3	45.54	643.9	883.8	
Av	50	15.25	72.9	3.79	53.6	73.6	

Determination of Water Rates of 60 HP Ideal Engine, Non Condensing, using Superheated Steam.

Conducted by,— H. H. Fricke, R. H. Sloane

Presented for,— Undergraduate Thesis, June 1, 1907

Test No — 1
Date,— March 30, '07
Duration,— 2 Hrs

Conditions,—
Load,— $\frac{1}{4}$
Pressure,— 113.5
Degree Superheat,— 164.5

No	Time	Pressures: Boiler	Pressures: Super-Heater	Pressures: Steam Chest	Pressures: Exhaust	Temperatures: Super Heater	Temperatures: Steam Chest	Temperatures: Exhaust	Degrees Superheat: Super-Heater	Degrees Superheat: Steam Chest	Degrees Superheat: Exhaust	Steam Cond Lbs.	R.P.M.	M.E.P.: H.E.	M.E.P.: C.E.	I.H.P.: H.E.	I.H.P.: C.E	I.H.P.: Total	Wt. on Scales Lbs.	B.H.P.	Mech. Effic. %	Therm. Effic. %	Lbs. Steam: I.H.P.Hr	Lbs. Steam: B.H.P.Hr	Remarks,—
1	9:20	124	121	127	3	635	515	231	284	161	9	0	305	16	23	9.65	13.68	23.33	50	15.25	65.4	0	0	0	
2	:30	125	122	120	3	623	523	231	272	173	9	190	312	17	20	10.50	12.18	22.68	"	15.60	69.0	3.98	50.3	73.0	
3	:40	116	114	117	2.5	615	521	229	269	173	9	191	310	15	20	9.21	12.10	21.31	"	15.50	72.8	3.7	53.8	74.0	
4	:50	110	109	118	2	607	517	229	264	158	10	186	303	19	19	11.40	11.25	22.65	"	15.15	70.0	4.1	49.3	70.5	
5	10:00	110	109	110	2	613	511	229	270	167	10	184	305	19	21	11.45	12.50	23.95	"	15.15	63.3	4.35	46.1	73.0	
6	:10	104	101	105	2	607	509	228	269	168	9	182	300	18	21	10.69	12.31	23.00	"	15.00	65.2	4.32	46.7	70.9	
7	:20	107	106	100	2.5	599	509	229	257	171	9	174	303	19	19	11.40	11.25	23.65	"	15.15	64.0	4.37	44.1	69.0	
8	:30	124	122	123	3.5	587	515	231	236	163	7	190	307	16	22	9.73	13.18	22.91	"	15.35	67.0	4.03	49.8	74.3	
9	:40	124	122	118	3	607	507	231	251	158	9	189	303	18	20	10.80	11.74	22.54	"	15.15	67.3	4.03	50.4	75.0	
10	:50	110	109	108	2	605	502	229	262	159	10	186	301	17	19	10.13	11.17	21.30	"	15.05	70.5	3.85	52.5	74.5	
11	11:00	104	102	102	2	605	505	228	265	166	9	180	302	15	17	8.96	10.03	18.99	"	15.10	79.5	3.55	51.0	71.7	
12	:10	107	105	106	2	607	507	228	266	165	9	173	303	16	17	9.60	10.06	19.66	"	15.15	77.1	3.82	52.8	68.5	
13	:20	118	116	121	4	603	507	230	255	156	5	178	304	17	21	10.23	12.47	22.70	"	15.20	67.0	4.25	47.5	70.8	
Total,		1483	1458	1475	3.35	7913	6648	2983	3420	2138	114	2203	3958	222	259	133.79	153.9	287.67	650	197.65	898.1	48.35	610.3	865.2	
Average,		114	112	113.5	2.6	608	511.7	229.5	263	164.5	8.77	184	304.2	17	19.9	10.3	11.8	22.01	50	15.2	69.1	4.06	50.8	72.	

Test No.— 2
Date,— April 26, '07
Duration,— 2 Hrs

Load,— $\frac{1}{4}$
Pressure,— 130.2
Degree Superheat,— 134.7

1	10:05	135	136	130	4	610	492	232	251	136	7	0	310	15.4	18.	9.45	10.90	20.34	50	15.50	76.2	0	0	0	
2	:15	120	119	127	3	607	492	227	258	139	5	187	307	18.	20.5	10.94	12.28	23.22	"	15.35	66.1	4.12	49.5	74.5	
3	:25	120	121	129	2.5	599	490	222	248	135	1	182	307	15.8	19.7	9.60	11.70	21.30	"	15.35	72.0	3.98	51.3	71.2	
4	:35	131	131	132	2.5	615	487	221	259	131	0	191	307	16.	19.7	9.66	11.72	21.38	"	15.25	71.5	3.80	53.6	75.0	
5	:45	132	133	130	2.5	609	489	223	252	133	2	193	304	16.4	19.4	9.87	11.52	21.39	"	15.20	71.0	3.76	54.1	76.2	
6	:55	134	133	132	2.	619	491	222	262	134	3	185	305	16.4	19.7	9.90	11.72	21.62	"	15.25	70.5	3.98	51.2	72.5	
7	11:05	125	125	128	2.	630	491	222	277	137	3	188	304	16.4	19.4	9.87	11.52	21.39	"	15.20	71.1	3.82	52.8	72.8	
8	:15	127	130	132	2.	605	494	222	249	137	3	175	304	15.8	19.6	9.51	11.64	21.15	"	15.20	72.0	4.07	49.6	69.0	
9	:25	133	132	136	2.	614	490	222	257	131	3	193	304	14.2	17.8	8.54	10.57	19.11	"	15.20	79.5	3.36	60.5	76.1	
10	:35	132	133	128	2.5	615	490	222	258	136	3	192	306	15.4	19.	9.33	11.34	20.67	"	15.30	74.0	3.64	55.7	75.2	
11	:45	125	126	127	2.	624	489	222	271	135	1	182	304	16.2	18.4	9.55	10.93	20.48	"	15.20	74.2	3.80	53.5	71.8	
12	:55	133	134	130	2.5	621	490	222	263	136	3	190	300	15.2	18.	9.03	10.55	19.58	"	15.00	76.6	3.47	58.2	76.0	
13	12:05	130	131	133	2.	615	489	223	259	132	1	186	303	15.6	19.	9.34	11.25	20.59	"	15.15	73.6	3.74	54.3	73.5	
Total		1677	1684	1694	31.5	7983	6374	2902	3364	1752	35	2244	3963	206.8	248.2	124.59	147.62	272.22	650	198.15	948.3	45.54	643.9	883.8	
Average		129	129.5	130.2	2.4	614	490	223	259	134.7	2.7	187	305	15.8	19.1	9.59	11.35	20.9	50	15.25	72.9	3.79	53.6	73.6	

CONDITIONS,—
LOAD — $\frac{1}{2}$
PRESSURE,— 110
DEGREE SUPERHEAT,— 169.7

THESIS
07'

No	WT. ON SCALES LBS.	B.H.P.	MECH. EFFIC.	THERM. EFFIC.	LBS. STEAM I.H.P.HR	LBS. STEAM B.H.P.HR	REMARKS,—
1	100	30.1	72.5	0	0	0	
2	"	30.2	81.	5.21	38.6	47.7	
3	"	30.2	84.6	4.91	40.7	47.1	
4	"	30.2	99.5	4.23	47.5	47.7	
5	"	30.3	90.8	4.75	42.5	45.6	
6	"	30.2	84.5	4.98	40.3	47.8	
7	"	30.	89.5	4.91	40.8	45.6	
8	"	30.	84.	5.02	39.9	47.5	
9	"	29.9	89.5	5.30	38.	42.5	
10	"	30.	83.5	5.61	35.7	42.8	
11	"	30.	79.8	5.62	35.8	45	
12	"	30.1	78.1	5.77	34.3	43.5	
13	"	30.1	83.0	5.39	37.1	44.6	
To	1300	391.5	1108	61.7	47.1	574.4	
Av	100	30.1	84.5	5.15	39.3	45.6	

LOAD,— $\frac{1}{2}$
PRESSURE,— 128
DEGREE SUPERHEAT,— 151.5

1	100	30.5	81	0	0	0	
2	"	30.0	80.2	5.80	34.6	43.1	
3	"	30.0	80.2	5.50	36.3	45.3	
4	"	30.0	82.	5.19	38.8	47.5	
5	"	30.2	82.2	5.09	39.4	48.	
6	"	30.0	83.5	5.53	36.4	44.	
7	"	30.3	84.	5.41	37.4	44.5	
8	"	30.3	85.5	5.08	39.8	46.6	
9	"	30.2	94.2	5.07	39.8	42.3	
10	"	30.1	82.5	5.03	40.1	48.6	
11	"	29.8	81.8	4.89	41.2	50.4	
12	"	29.8	94.5	4.59	43.5	46.	
13	"	29.8	82.5	5.01	40.3	48.8	
To	1300	391	1094.1	62.19	467.6	555.1	
Av	100	30.1	84.1	5.18	39	46.2	

Log & Data Sheet.

Determination of Water Rates of 60 H.P. Ideal Engine, Non Condensing, Using Superheated Steam.

Conducted by,— H. H. Fricke, R. H. Sloane

Presented for,— Undergraduate Thesis, June 1, 1907

Test No. — 3
Date,— March 30 '07
Duration,— 2 Hrs

Conditions —
Load — $\frac{1}{2}$
Pressure, — 110
Degree Superheat 169.7

No.	Time	Pressures: Boiler	Pressures: Superheater	Pressures: Steam Chest	Pressures: Exhaust	Temperatures: Superheater	Temperatures: Steam Chest	Temperatures: Exhaust	Degrees Superheat: Superheater	Degrees Superheat: Steam Chest	Degrees Superheat: Exhaust	Steam Cond. Lbs.	R.P.M.	M.E.P. H.E.	M.E.P. C.E.	I.H.P. H.E.	I.H.P. C.E.	I.H.P. Total	Wt. on Scales Lbs.	B.H.P.	Mech. Effic.	Therm. Effic.	Lbs Steam I.H.P. Hr	Lbs Steam B.H.P. Hr	Remarks.
1	11:30	110	110	107	4	605	517	232	261	174	7	0	301	36	34.3	21.44	20.11	41.55	100	30.1	72.5	0	0	0	
2	:40	119	117	117	5	597	519	234	249	171	7	240	302	32	31.	18.98	18.29	37.27	"	30.2	81.	5.21	38.6	47.7	
3	:50	126	125	120	5	599	521	234	246	161	7	242	302	28	32.5	16.73	19.	35.73	"	30.2	84.6	4.91	40.7	47.1	
4	12:00	125	123	122	4	579	519	233	227	168	8	240	302	25	26.2	14.98	15.46	30.39	"	30.2	99.5	4.23	47.5	47.7	
5	:10	129	126	123	3.5	605	515	234	252	163	11	240	303	28	28.	16.80	16.58	33.38	"	30.3	90.8	4.75	42.5	45.6	
6	:20	130	127	116	3	609	520	231	255	172	9	244	302	28	32.2	16.70	19.	35.70	"	30.2	84.5	4.98	40.3	47.8	
7	:30	112	110	110	3	597	521	231	253	177	9	228	300	30	27.	17.82	15.7	33.52	"	30.	89.5	4.91	40.8	45.6	
8	:40	108	106	110	3	603	517	231	261	175	9	238	300	28	31.	16.63	18.16	35.79	"	30.	84.	5.02	39.9	47.5	
9	:50	105	103	103	3	605	515	229	245	165	7	212	299	30	27.	17.76	15.77	33.53	"	29.9	89.5	5.30	38.	42.5	
10	1:00	106	105	105	3	575	514	231	234	173	9	214	300	30	31.	17.82	18.16	35.97	"	30.	83.5	5.61	35.7	42.8	
11	:10	95	93	90	4	611	500	231	278	169	6	225	300	30	33.8	17.82	19.81	37.63	"	30.	79.8	5.62	35.8	45	
12	:20	105	103	100	4.5	605	506	232	255	168	4	219	301	31	34.2	18.47	20.11	38.58	"	30.1	78.1	5.77	34.3	43.5	
13	:30	108	108	108	4	611	515	232	268	172	7	224	301	28	33.2	16.69	19.52	36.21	"	30.1	83.0	5.39	37.1	44.6	
Total,		1480	1456	1431	49	7801	6699	3015	3284	2208	100	2766	3915	384	403	228.6	235.67	465.25	1300	391.5	1108	61.7	47.1	574.4	
Average,		113.8	112	110	3.77	600	515	232	252	169.7	7.6	230	301	29.5	31	17.58	18.12	35.8	100	301	84.5	5.15	39.3	45.6	

Test No. — 4
Date,— April 26, '07
Duration,— 2 Hrs.

Load,— $\frac{1}{2}$
Pressure,— 128
Degree Superheat,— 151.5

1	4:40	139	140	140	4	615	515	227	254	154	2	0	305	29.8	33	18.	19.64	37.64	100	30.5	81	0	0	0	
2	:50	122	122	123	2	625	512	222	274	160	3	216	300	31.4	32	18.65	18.75	37.40	"	30.0	80.2	5.80	34.6	43.1	
3	5:00	115	123	125	3.5	617	521	226	275	178	3	226	300	31.2	32.2	18.53	18.87	37.40	"	30.0	80.2	5.50	36.3	45.3	
4	:10	127	116	115	3	615	516	225	267	159	3	237	300	30.6	31.5	18.17	18.46	36.63	"	30.0	82.	5.19	38.8	47.5	
5	:20	126	127	132	4	605	506	227	251	152	2	241	302	30.2	31.7	18.05	18.70	36.75	"	30.2	82.2	5.09	39.4	48.	
6	:30	124	126	127	3	601	499	226	248	145	4	217	300	28.6	32.2	17.	18.87	35.87	"	30.0	83.5	5.53	36.4	44.	
7	:40	126	125	131	3.5	605	497	227	252	141	4	225	303	29.	31.7	17.4	18.77	36.17	"	30.3	84.	5.41	37.4	44.5	
8	:50	127	127	130	2.5	615	497	223	261	141	3	235	303	29.	30.5	17.4	18.06	35.46	"	30.3	85.5	5.08	39.8	46.6	
9	6:00	126	127	130	2	605	501	222	251	144	3	212	302	27.	27.	16.15	15.93	32.08	"	30.2	94.2	5.07	39.8	42.3	
10	:10	127	127	128	2	635	503	222	281	149	3	238	301	28.6	33.2	17.05	19.52	36.57	"	30.1	82.5	5.03	40.1	48.6	
11	:20	125	128	128	3	605	507	225	251	153	3	243	298	28.8	33.6	16.89	19.56	36.45	"	29.8	81.8	4.89	41.2	50.4	
12	:30	122	125	127	3	615	503	225	262	149	3	229	298	26.	28.	15.34	16.18	31.52	"	29.8	94.5	4.59	43.5	46.	
13	:40	125	126	127	3	610	499	225	257	145	3	243	298	29.6	32.2	17.46	18.73	36.19	"	29.8	82.5	5.01	40.3	48.8	
Total		1631	1639	1663	38.5	7968	6576	2922	3384	1970	39	2762	3910	379.8	407.8	226.1	240	466.13	1300	391	1094.1	62.19	467.6	555.1	
Average		125.5	126	128	2.7	613	503	225	260	151.5	3	238	301	29.2	31.4	17.4	18.4	35.88	100	30.1	84.1	5.18	39	462	

THESIS
07

CONDITIONS,—
LOAD — $\frac{3}{4}$
PRESSURE,— 115
DEGREE SUPERHEAT 169.5

No.	Motion Scales Lbs.	R.H.P.	Mech. Effic.	Therm. Effic.	Lbs. Steam I.H.P. Hr	Lbs. Steam B.H.P. Hr	Remarks,—
1	147	44.84	78.4	0	0	0	
2	1 "	44.34	75.3	6.84	29.2	38.8	
3	"	45.14	84.3	6.15	32.5	38.2	
4	"	44.34	84.5	5.68	35.2	41.6	
5	"	44.4	78.2	6.52	30.7	39.3	
6	"	44.55	74.3	6.93	29.0	39.0	
7	"	44.55	106.5	4.84	41.5	38.9	
8	"	44.55	99.0	5.14	39.0	39.4	
9	"	44.55	81.0	5.91	31.3	38.6	
10	"	44.7	68.0	8.19	24.6	36.2	
11	"	44.9	103.0	5.11	39.1	37.9	
12	"	44.7	118.5	4.56	44.0	37.1	
13	"	44.9	83.5	6.48	31.1	37.2	
Tot	1911	580.46	1134.5	72.35	406.2	462.2	
Av.	147	44.65	87.2	6.03	33.8	38.5	

LOAD,— $\frac{3}{4}$
PRESSURE,— 125
DEGREE SUPERHEAT,—156.5

1	147	44.84	83.5	0	0	0	
2	"	44.9	84.9	5.84	34.4	41.0	
3	"	44.84	87.0	5.59	35.9	41.3	
4	"	44.84	88.8	5.52	36.4	41.0	
5	"	44.9	88.5	5.5	36.5	41.3	
6	"	44.9	85.2	6.22	32.4	38.0	
7	"	44.84	87.0	6.77	29.7	34.2	
8	"	44.9	87.4	6.38	31.5	36.1	
9	"	44.9	90.5	6.45	31.3	34.6	
10	"	44.84	105.5	4.63	43.5	41.2	
11	"	44.84	83.0	579	34.7	42.0	
12	"	44.9	90.0	7.16	28.2	31.4	
13	"	44.9	87.5	6.39	31.5	36.0	
Tot	1191	583.34	1148.8	72.24	406.1	458.1	
Av.	147	44.87	88.3	6.02	33.75	38.15	

DETERMINATION OF WATER RATES OF 60 HP CORLISS ENGINE
NON CONDENSING, USING SUPERHEATED STEAM
TESTED BY,— H H FRICKE, R H SHANE
PRESENTED FOR,— UNDERGRADUATE THESIS
JUNE 1, 1907

Test No. 5
Date,— MARCH 28, '07
Duration,— 2 Hrs

Load — $\frac{3}{4}$
Pressure — 115
Degree Superheat 169.5

Time	Pressures: Boiler	Super Heater	Steam Chest	Exhaust	Temperatures: Super Heater	Steam Chest	Exhaust	Degrees Superheat: Steam Chest	Exhaust	Steam Cond. Lbs.	RPM	M.E.P.: H.E.	C.E.	I.H.P.: H.E.	C.E.	Total	Coal Lbs.	R.H.P.	Mech. Effic.	Therm Effic.	Lbs Steam: I.H.P.Hr	R.H.P.Hr	Remarks
1:20	98	95	87	6	615	527	236	278	198	5	0	303	50	46	30	27.2	57.2	147	44.84	78.4	0	0	0
:30	104	100	100	6	605	519	236	265	181	5	287	299	50	48.5	30.1	28.8	58.9	1 "	44.34	75.3	6.84	29.2	38.8
:40	128	125	126	6.5	583	522	238	230	169	6	291	305	46	44	27.6	26.	53.6	"	45.14	84.3	6.15	32.5	38.2
:50	120	117	117	6.	571	517	237	223	169	6	308	299	48	40	28.8	23.7	52.5	"	44.34	84.5	5.68	35.2	41.6
2:00	114	112	110	5.5	611	513	235	206	169	6	290	300	50	44.8	30.1	26.6	56.7	"	44.4	78.2	6.52	30.7	39.3
:10	111	107	104	5.	581	517	236	239	167	8	290	301	42	42.	35.1	24.9	60.	"	44.55	74.3	6.93	29.0	39.0
:20	109	106	107	5.5	585	515	237	243	163	8	285	301	36	34.2	21.6	20.2	41.8	"	44.55	106.5	4.84	41.5	38.9
:30	111	108	112	7.	597	523	237	254	168	4	293	301	38	37.5	22.9	22.2	45.1	"	44.55	99.0	5.14	39.0	39.4
:40	117	114	125	4.	583	518	230	236	165	5	287	301	50	42.	30.1	24.9	55	"	44.55	81.0	5.91	31.3	38.6
:50	130	128	133	25	605	513	225	250	156	6	270	302	58	52.5	34.8	31.	65.8	"	44.7	68.0	8.19	24.6	36.2
3:00	127	125	125	3.5	605	518	229	252	165	6	285	304	38	35.2	22.8	20.8	43.6	"	44.9	103.0	5.11	39.1	37.9
:10	124	122	128	3.	595	519	229	254	164	7	275	302	30	33.2	18.	19.7	37.7	"	44.7	118.5	4.56	44.0	37.1
:20	123	121	120	3.5	593	517	229	247	167	6	279	304	46	44	27.7	26.1	53.8	"	44.9	83.5	6.48	31.1	37.2
Total	1516	1480	1494	64.	7729	6738	3034	3237	2201	76	3410	3922	582	544.9	357.9	322.1	681.7	1911	580.46	1134.5	72.35	406.2	462.2
Average	116.6	113.8	115	4.92	594	518	233	249	169.5	5.85	262	302	44.8	41.9	27.6	24.75	52.5	147	44.65	87.2	6.03	33.8	38.5

Test No. — 6
Date,— MARCH 28, '07
Duration,— 2 Hrs.

Load.— $\frac{3}{4}$
Pressure,— 125
Degree Superheat,— 156.5

3:30	121	120	119	4.5	593	516	230	243	167	3	0	303	46	44	27.6	26.	53.6	147	44.84	83.5	0	0	0
:40	124	122	122	4.5	595	512	230	244	161	3	303	304	46	44	27.2	25.7	52.9	"	44.9	84.9	5.84	34.4	41.0
:50	130	128	127	4.	601	511	227	246	157	2	308	303	44	42	26.5	25.	51.5	"	44.84	87.0	5.59	35.9	41.3
4:00	132	130	130	5.	595	513	228	239	157	1	306	303	44	42	26.5	24.5	50.5	"	44.84	88.8	5.52	36.4	41.0
:10	129	127	126	4.5	599	514	227	244	161	0	307	304	44	42	26.1	24.6	50.7	"	44.9	88.5	5.5	36.5	41.3
:20	117	116	116	4.	603	513	227	255	165	2	285	304	45	44	26.8	25.9	52.7	"	44.9	85.2	6.22	32.4	38.0
:30	108	106	106	3.5	600	507	226	258	165	2	255	303	45	42	26.8	24.7	51.5	"	44.84	87.0	6.77	29.7	34.2
:40	125	123	127	3.5	611	503	228	259	149	4	270	304	46	40.8	27.4	24	51.4	"	44.9	87.4	6.38	31.5	36.1
:50	137	135	130	5.	605	501	230	247	145	2	259	304	44	39.8	26.2	23.4	49.6	"	44.9	90.5	6.45	31.3	34.6
5:00	135	134	133	5.	593	509	234	235	152	6	308	303	38	33.3	22.7	19.7	42.4	"	44.84	105.5	4.63	43.5	41.2
:10	127	126	126	3.	613	512	227	260	159	5	303	303	45	45.2	27.1	26.8	53.9	"	44.84	83.0	5.79	34.7	42.0
:20	137	135	142	3.	605	501	226	247	139	4	235	304	42	42	25.1	24.8	49.9	"	44.9	90.0	7.16	28.2	31.4
:30	130	128	120	4.	585	504	230	230	154	5	270	304	42	44	25.3	26.1	51.4	"	44.9	87.5	6.39	31.5	36.0
Total	1652	1630	1624	55.5	7898	6616	2970	3207	2031	39	3439	3946	571	545.1	340.8	321.2	66.2	1191	583.34	1148.8	72.24	406.1	458.1
Average	127	125.4	125	4.1	607	509	228.5	247	156.5	3	264.5	265	43.9	41.6	28.4	24.5	50.93	147	44.87	88.3	6.02	33.75	38.15

THESIS
07

CONDITIONS,—
LOAD,— FULL
PRESSURE,— 142.8
DEGREE SUPERHEAT,— 166.5

No	Wt. on Scales Lbs.	B.H.P.	Mech. Effic.	Therm. Effic.	Lbs. Steam I.H.P.Hr	Lbs. Steam B.H.P.Hr	Remarks,—
1	200	61.	83.8	0	0	0	
2	"	60.6	91.5	6.08	33.0	37.1	
3	"	60.	89.3	6.31	31.7	34.0	
4	"	60.6	93.8	6.08	33.0	35.2	
5	"	60.6	91.6	5.88	34.0	36.1	
6	"	60.6	86.3	6.51	30.7	35.6	
7	"	60.8	89.8	6.33	31.4	33.8	
8	"	60.6	92.1	6.20	32.2	34.9	
9	"	61.	87.5	6.76	29.5	33.7	
10	"	61.2	89.6	6.72	29.9	33.4	
11	"	61.	90.6	6.22	32.1	35.3	
12	"	61.2	91.1	6.32	31.6	34.7	
13	"	61.	89.5	6.4	31.2	34.9	
To	2600	7902	1166.5	7581	380.3	418.7	
Av	200	60.8	89.7	6.32	31.7	34.8	

LOAD,— FULL
PRESSURE,— 141.3
DEGREE SUPERHEAT,— 166.6

1	200	61.0	89.5	0	0	0	
2	"	61.2	91.8	6.41	31.2	34.4	
3	"	60.0	95.5	5.97	33.4	35.5	
4	"	60.8	87.6	6.61	30.2	35.4	
5	"	60.8	91.9	6.26	31.9	34.7	
6	"	61.2	88.5	6.46	30.9	34.9	
7	"	61.4	90.0	6.41	31.2	34.7	
8	"	62.0	88.8	6.38	31.3	35.2	
9	"	62.0	81.4	7.12	28.1	34.6	
10	"	63.8	85.4	7.06	28.4	33.3	
11	"	63.0	87.8	6.88	29.2	33.3	
12	"	62.0	87.0	6.68	30.0	34.5	
13	"	61.0	86.5	6.66	30.1	34.8	
To	2600	799.1	1151.5	789	365.9	415.3	
Av	200	61.5	88.6	6.57	30.5	346	

Log & Data Sheet.

Determination of Water Rates of 60 HP Ideal Engine, Non-Condensing, using Superheated Steam.

Conducted by,— H. H. Fricke, R. H. Sloane

Presented for,— Undergraduate Thesis, June 1, 1907

Test No.— 7
Date,— April 26, '07
Duration,— 2 Hrs.

Conditions,—
Load,— Full
Pressure,— 142.8
Degree Superheat,— 166.5

No.	Time	Pressures				Temperatures			Degrees Superheat			Steam Cond. Lbs.	R.P.M.	M.E.P.		I.H.P.			Wt. on Scales Lbs.	B.H.P	Mech. Effic.	Therm. Effic.	Lbs. Steam		Remarks,—
		Boiler	Super-heater	Steam Chest	Exhaust	Super-heater	Steam Chest	Exhaust	Super-heater	Steam Chest	Exhaust			H.E.	C.E.	H.E.	C.E.	Total					I.H.P.Hr.	B.H.P.Hr.	
1	12:35	143	144	145	8	615	522	237	252	169	2	0	305	60	61.5	36.24	36.59	72.83	200	61.	83.8	0	0	0	
2	:45	140	141	143	8	615	525	238	254	164	3	365	303	57	54.3	34.20	32.15	66.35	"	60.6	91.5	6.08	33.0	37.1	
3	:55	145	146	145	6	615	524	238	251	161	7	355	300	57.4	56.5	34.10	33.11	67.21	"	60.	89.3	6.31	31.7	34.0	
4	1:05	144	145	147	7	615	526	238	252	161	5	356	303	52.6	56	31.56	33.15	64.71	"	60.6	93.8	6.08	33.0	35.2	
5	:15	137	138	140	7	619	529	238	259	169	5	344	303	55.8	55.2	33.48	32.68	66.16	"	60.6	91.6	5.88	34.0	36.1	
6	:25	143	143	143	9	615	529	239	253	167	1	360	303	59.8	58.2	35.88	34.45	70.33	"	60.6	86.3	6.51	30.7	35.6	
7	:35	143	143	143	8	619	535	238	257	173	3	355	304	57.6	55.7	34.68	33.09	67.77	"	60.8	89.8	6.33	31.4	33.8	
8	:45	139	138	140	6	615	532	237	254	171	4	353	303	56.2	54.3	33.72	32.15	65.87	"	60.6	92.1	6.20	32.2	34.9	
9	:55	142	145	144	6	613	533	238	252	169	7	342	305	59.	57	35.64	33.92	69.56	"	61.	87.5	6.76	29.5	33.7	
10	2:05	145	143	142	6	607	519	237	245	157	6	340	306	56.	57.5	33.94	34.32	68.26	"	61.2	89.6	6.72	29.9	33.4	
11	:15	144	143	144	7	615	527	238	253	163	5	360	305	56.4	56.	34.07	33.32	67.39	"	61.	90.6	6.22	32.1	35.3	
12	:25	142	142	143	6	613	532	237	251	169	6	354	306	55.6	56	33.69	33.43	67.12	"	61.2	91.1	6.32	31.6	34.7	
13	:35	140	140	138	6	615	529	237	254	169	6	354	305	57.2	56.7	34.55	33.62	68.17	"	61.	89.5	6.4	31.2	34.9	
Total,		1847	1851	1857	90	7991	6862	3090	3287	2162	60	4238	3951	740.4	734.7	445.79	435.98	881.73	2600	790.2	1166.5	7581	380.3	418.7	
Average,		142	142.4	142.8	6.9	615	528	238	253	166.5	4.6	353	304	56.9	56.5	34.3	33.5	67.8	200	60.8	89.7	6.32	31.7	34.8	

Test No.— 8
Date,— April 26, '07
Duration,— 2 Hrs

Load,— Full
Pressure,— 141.3
Degree Superheat,— 166.6

1	2:35	140	140	138	6	615	529	237	254	169	6	0	305	57.2	56.5	34.55	33.62	68.17	200	61.0	89.5	0	0	0	
2	:45	145	147	143	7	615	523	237	251	161	4	346	306	54.6	56.	33.09	33.43	66.52	"	61.2	91.8	6.41	31.2	34.4	
3	:55	135	134	133	6	617	525	237	259	176	6	350	300	54.6	52.	32.43	30.47	62.90	"	60.0	95.5	5.97	33.4	35.5	
4	3:05	131	131	138	6	615	535	234	259	175	3	347	304	58.	56.5	35.92	33.56	69.48	"	60.8	87.6	6.61	30.2	35.4	
5	:15	142	143	144	8	629	531	238	267	168	3	353	304	54.8	56.	33.01	33.26	66.27	"	60.8	91.9	6.26	31.9	34.7	
6	:25	140	140	143	7	621	531	235	260	169	2	356	306	57.4	57.3	34.78	34.27	69.07	"	61.2	88.5	6.46	30.9	34.9	
7	:35	135	136	138	6	607	530	237	248	170	6	355	307	57.4	57.	33.90	34.24	68.14	"	61.4	90.0	6.41	31.2	34.7	
8	:45	135	135	138	6	622	527	237	264	167	6	365	310	57.6	57.3	35.37	34.61	69.98	"	62.0	88.8	6.38	31.3	35.2	
9	:55	140	141	143	7	609	527	240	208	165	7	358	310	62.6	64.5	38.44	38.02	76.46	"	62.0	81.4	7.12	28.1	34.6	
10	4:05	141	141	143	9	609	523	239	248	161	1	355	319	60.8	58.5	38.42	36.44	74.86	"	63.8	85.4	7.06	28.4	33.3	
11	:15	145	146	144	8	625	527	241	258	164	6	354	315	59.4	57.7	37.09	35.48	72.57	"	63.0	87.8	6.88	29.2	33.3	
12	:25	145	143	143	6	607	525	235	232	163	4	361	310	60.	58.5	36.84	35.39	72.23	"	62.0	87.0	6.68	30.0	34.5	
13	:35	145	146	148	7	615	525	235	240	160	2	355	305	58.4	59.5	35.29	35.40	70.69	"	61.0	86.5	6.66	30.1	34.8	
Total		1819	1823	1836	89	8006	6858	3082	3248	2168	56	4255	4001	752.8	747.3	459.13	448.19	907.32	2600	799.1	1151.5	789	365.9	415.3	
Average.		140	140.2	141.3	6.8	616	527	237	250	166.6	4.3	354	307.5	57.9	56.5	353.5	344.8	69.78	200	61.5	88.6	6.57	30.5	346	

THESIS
07

CONDITIONS,—
LOAD,— $1\frac{1}{4}$
PRESSURE,— 134.5
DEGREE SUPERHEAT,— 152.5

No	Wt. on Scales Lbs.	B.H.P.	Mech. Effic. %	Therm. Effic. %	Lbs. Steam I.H.P.Hr	Lbs. Steam B.H.P.Hr	Remarks,—
1	250	74.5	90.5	0	0	0	
2	"	74.8	85.6	7.4	26.7	31.2	
3	"	75.	86.0	7.7	26.1	30.4	
4	"	76.	80.	7.95	25.6	32.	
5	"	75.	76.8	7.3	28.1	36.6	
6	"	74.	76.7	7.38	27.1	35.3	
7	"	75.	77.2	7.96	25.1	32.5	
8	"	75.5	77.8	8.21	24.4	31.4	
9	"	76.2	85.	7.59	26.4	31.0	
10	"	75.	80.4	7.93	25.3	31.5	
11	"	75.	77.2	8.27	24.3	31.5	
12	"	76.2	79.5	7.69	26.1	32.9	
13	"	74.5	76.2	7.79	25.8	33.9	
To	3250	975.5	1058.9	93.17	311.0	3902.	
Av	250	75.1	81.4	7.76	25.9	32.5	

LOAD,— $1\frac{1}{4}$
PRESSURE,— 139.9
DEGREE SUPERHEAT,— 157

1	250	75.5	77.2	0	0	0	
2	"	75.	78.6	7.6	26.4	33.6	
3	"	74.5	78.	8.23	24.3	31.2	
4	"	75.	81.7	7.88	25.5	31.2	
5	"	74.5	79.6	8.12	24.7	31.	
6	"	74.5	78.5	8.33	24.1	30.7	
7	"	75.	80.5	7.78	25.8	32.	
8	"	75.	79.5	8.25	24.3	30.5	
9	"	74.5	81.2	8.08	25.2	31.	
10	"	74.5	81.	8.1	24.8	30.6	
11	"	75.	79.5	8.21	24.5	30.8	
12	"	75.	86.7	7.37	27.4	31.6	
13	"	74.8	82.5	7.76	25.9	31.4	
To	3250	972.8	1034.5	95.71	302.9	375.7	
Av	250	74.8	80.3	7.97	25.2	31.3	

Log & Data Sheet.

Determination of Water Rates of 60 HP Ideal Engine, Non-Condensing, using Superheated Steam.

Conducted by,— H. H Fricke, R. H. Sloane

Presented for,— Undergraduate Thesis, June 1, 1907

Test No.— 9
Date,— May 3, '07
Duration,— 2 Hrs.

Conditions,—
Load,— $1\frac{1}{4}$
Pressure,— 134.5
Degree Superheat,— 152.5

No.	Time	Pressures: Boiler	Pressures: Superheater	Pressures: Steam Chest	Pressures: Exhaust	Temperatures: Superheater	Temperatures: Steam Chest	Temperatures: Exhaust	Degrees Superheat: Superheater	Degrees Superheat: Steam Chest	Degrees Superheat: Exhaust	Steam Cond. Lbs.	R.P.M.	M.E.P. H.E.	M.E.P. C.E.	I.H.P. H.E.	I.H.P. C.E.	I.H.P. Total	Wt. on Scales Lbs.	B.H.P.	Mech. Effic. %	Therm. Effic. %	Lbs. Steam / I.H.P.Hr	Lbs. Steam / B.H.P.Hr	Remarks,—
1	9:35	122	121	104	7	607	507	234	256	167	1	0	298	68.	72.3	40.12	42.08	82.2	250	74.5	90.5	0	0	0	
2	:45	125	123	125	6	609	497	233	257	144	3	388	299	75.2	73.4	44.51	42.87	87.38	"	74.8	85.6	7.4	26.7	31.2	
3	:55	144	145	142	7	627	514	236	264	152	3	379	300	70.	78.	44.58	45.71	87.29	"	75.	86.0	7.7	26.1	30.4	
4	10:05	145	145	138	7	607	470	237	244	110	4	405	304	82.	76.8	49.36	45.62	94.98	"	76.	80.	7.95	25.6	32.	
5	:15	145	144	138	10	617	453	245	254	93	5	450	300	82.8	82.6	49.18	48.4	97.58	"	75.	76.8	7.3	28.1	36.6	
6	:25	145	145	135	9	617	515	240	254	157	2	435	296	84.8	80.8	49.69	46.7	96.39	"	74.	76.7	7.38	27.1	35.3	
7	:35	141	140	138	9	611	530	240	250	170	2	406	300	82.6	82.2	49.06	48.17	97.23	"	75.	77.2	7.96	25.1	32.5	
8	:45	141	142	137	9	617	532	240	249	173	2	395	302	83.0	80.4	49.63	47.44	97.07	"	75.5	77.8	8.21	24.4	31.4	
9	:55	141	141	140	9	627	523	238	265	162	0	395	305	76.0	72.	46.90	42.84	89.74	"	76.2	85.	7.59	26.4	31.0	
10	11:05	141	142	137	$9\frac{1}{2}$	609	527	240	247	168	1	393	300	76.0	82.2	45.14	48.17	93.31	"	75.	80.4	7.93	25.3	31.5	
11	:15	141	140	138	$9\frac{1}{2}$	597	522	240	236	162	1	393	300	84.8	76.0	52.74	44.54	97.28	"	75.	77.2	8.27	24.3	31.5	
12	:25	141	141	137	10	612	521	241	256	162	1	415	298	84.8	78.5	50.03	45.69	95.72	"	76.2	79.5	7.69	26.1	32.9	
13	:35	141	140	137	10	622	521	241	261	162	1	420	300	84.4	78.0	50.13	45.71	97.84	"	74.5	76.2	7.79	25.8	33.9	
Total,		1813	1809	1746	112	7979	6631	3105	3293	1982	26	4874	3902	1034.4	1013.2	618.07	593.94	1212.01	3250	975.5	1058.9	93.17	311.0	3902.	
Average,		139.5	139	134.5	8.6	612	510	239	253	152.5	2	406	300	79.6	78	47.5	45.6	93.3	250	75.1	81.4	7.76	25.9	32.5	

Test No.— 10
Date,— May 3, '07
Duration,— 2 Hrs.

Load,— $1\frac{1}{4}$
Pressure,— 139.9
Degree Superheat,— 157

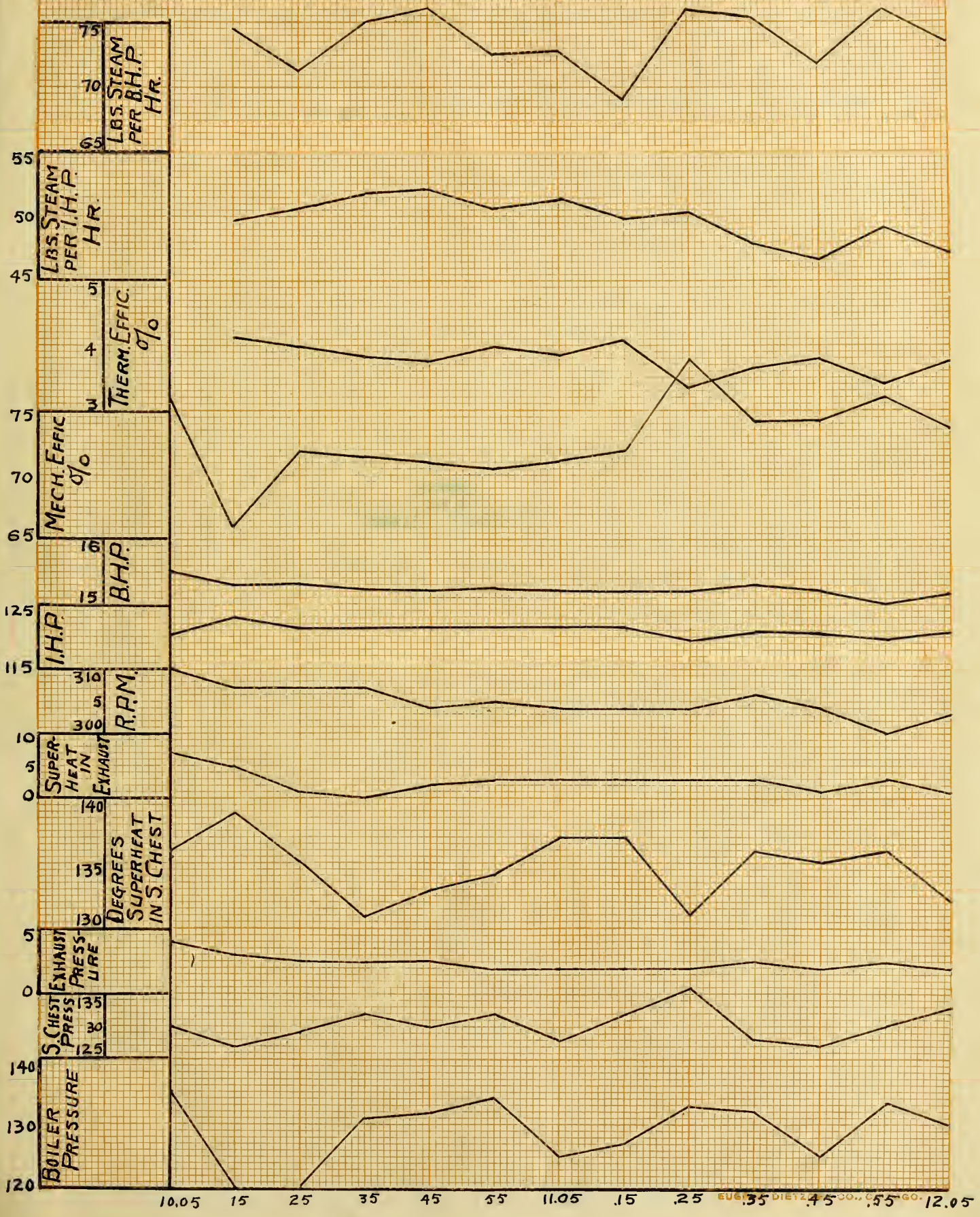
1	11:35	141	140	137	10	612	516	243	251	157	3	0	300	84.4	78	50.13	45.71	97.84	250	75.5	77.2	0	0	0	
2	:45	141	140	137	10	622	516	242	261	157	2	420	302	80	80.6	47.84	47.55	95.39	"	75.	78.6	7.6	26.4	33.6	
3	55	142	142	140	9	615	517	242	253	156	4	387	300	84	76.	49.9	45.71	95.61	"	74.5	78.	8.23	24.3	31.2	
4	12:05	141	141	138	$9\frac{1}{2}$	623	516	241	262	156	2	390	298	80.4	76.2	47.44	45.71	91.79	"	75.	81.7	7.88	25.5	31.2	
5	:15	144	144	140	10	611	524	242	248	163	2	385	298	80	79.8	47.2	44.35	93.64	"	74.5	79.6	8.12	24.7	31.	
6	:25	143	144	142	10	617	525	242	245	163	2	380	298	82	80.	48.38	46.44	94.94	"	74.5	78.5	8.33	24.1	30.7	
7	:35	142	142	140	9	621	527	240	259	166	2	400	300	78	79.8	46.33	46.56	93.09	"	75.	80.5	7.78	25.8	32.	
8	:45	143	142	143	8	607	524	238	245	162	3	382	300	80	80.	47.52	46.76	94.4	"	75.	79.5	8.25	24.3	30.5	
9	:55	143	144	140	9	607	518	240	244	157	2	385	298	81	75.5	47.79	46.88	91.73	"	74.5	81.2	8.08	25.2	31.	
10	1:05	139	138	138	9	615	515	241	255	155	3	380	298	78	78.	46.61	43.94	92.01	"	74.5	81.	8.1	24.8	30.6	
11	:15	143	142	145	6	607	511	235	245	148	5	386	300	82	78.	48.71	45.40	94.42	"	75.	79.5	8.21	24.5	30.8	
12	:25	143	141	140	7	609	507	240	248	146	7	390	300	72	72.8	42.77	42.66	85.43	"	75.	86.7	7.37	27.4	31.6	
13	:35	141	140	140	9	619	517	232	258	156	—	392	299	78	76.2	46.18	44.50	90.68	"	74.8	82.5	7.76	25.9	31.4	
Total		1846	1840	1820	114.5	7985	6733	3118	3274	2042	37	4677	3891	1039.8	1012.9	616.8	592.77	1210.97	3250	972.8	1034.5	95.71	302.9	375.7	
Average		142	141.5	139.9	8.8	614	518	239.7	252	157	3.18	389	299	80	78	47.45	45.6	93.2	250	74.8	80.3	7.97	25.2	31.3	

Test of Ideal Engine with Superheated Steam

Graphic Log — Test No. 2, April 26, 07

Load, – 1/4

Fricke & Sloane



TEST OF IDEAL ENGINE WITH SUPERHEATED STEAM

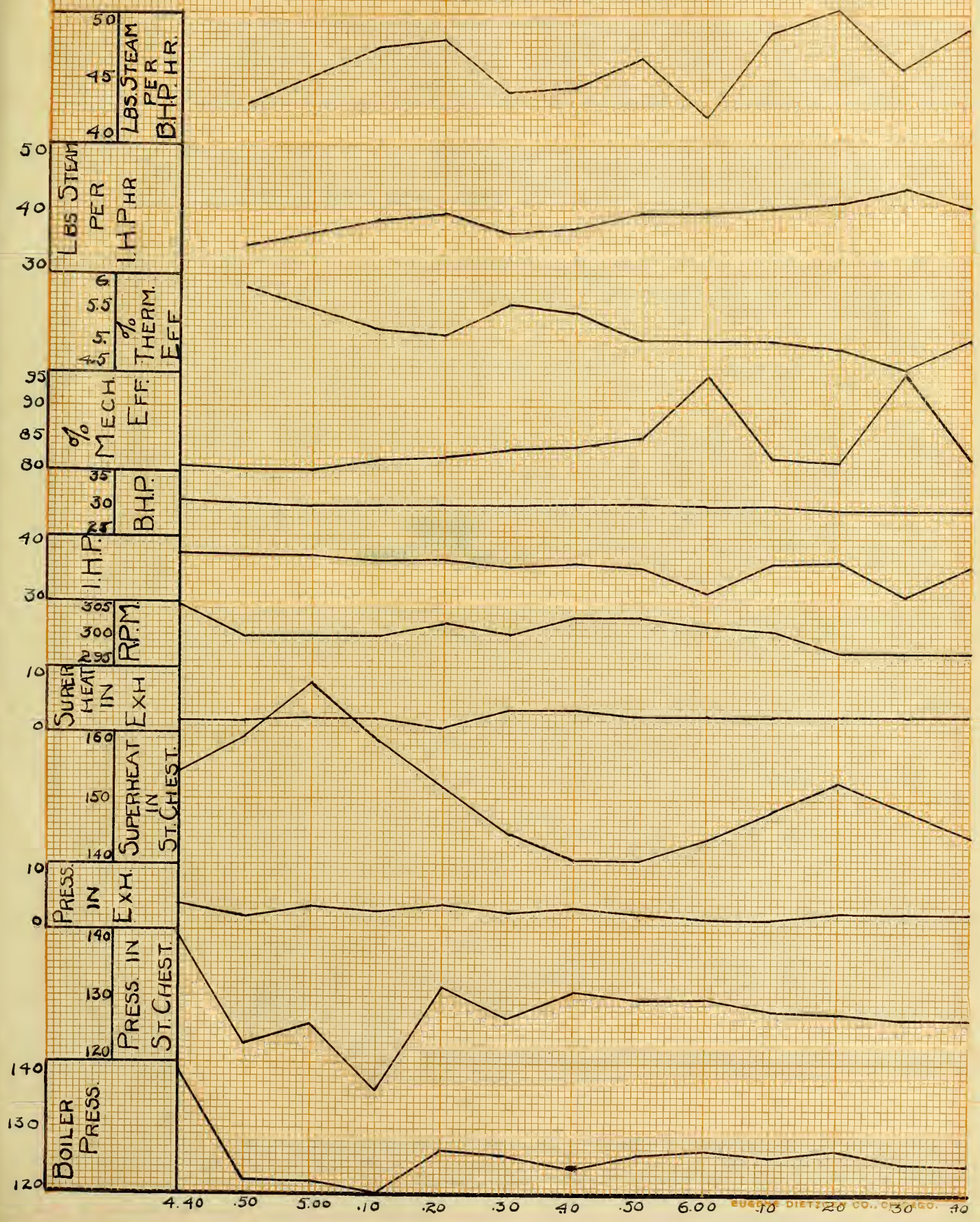
GRAPHIC LOG

LOAD, $\frac{1}{2}$

TEST No 4.

APRIL 26, 07

FRICKE AND SLOANE.

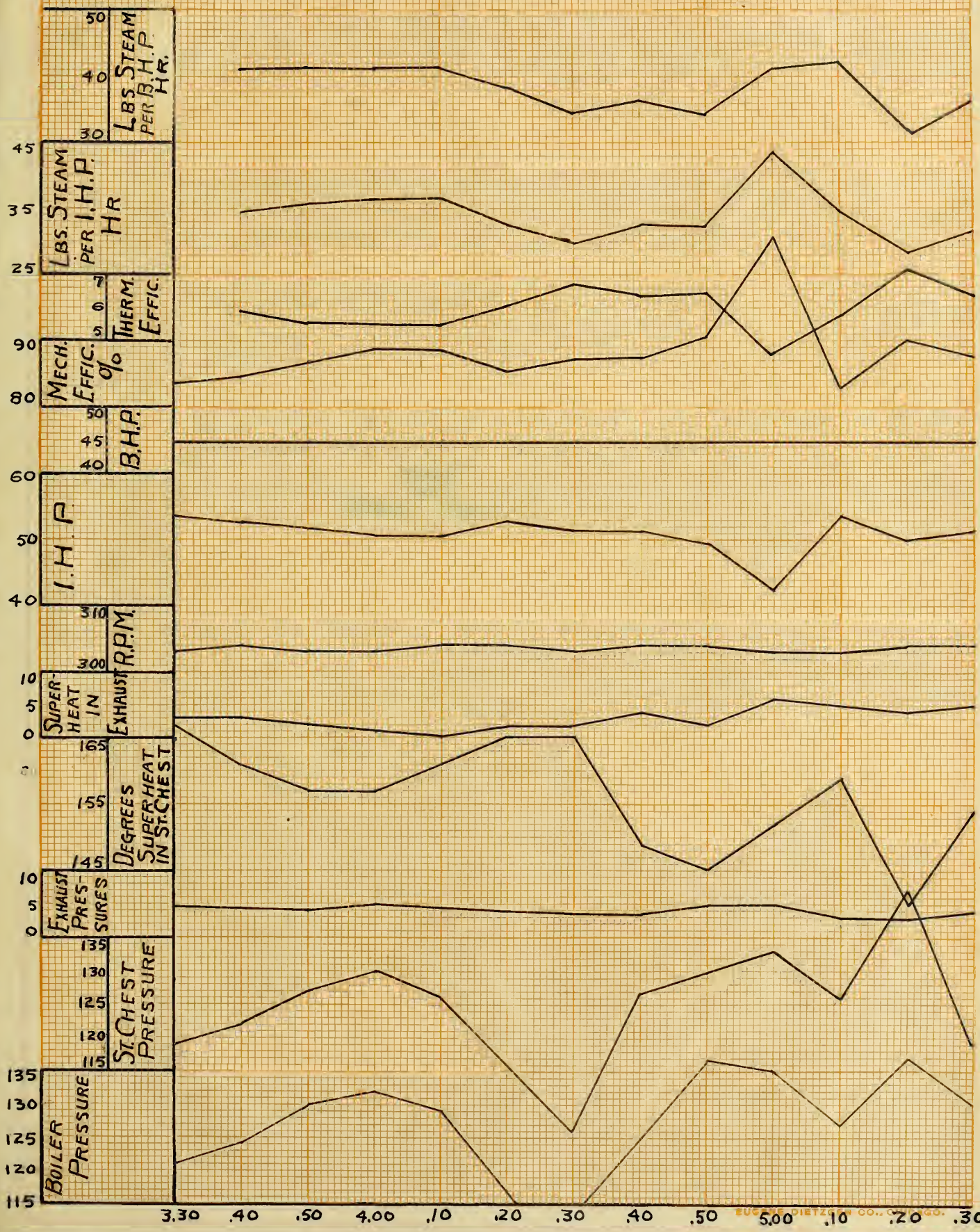


TEST OF IDEAL ENGINE WITH SUPERHEATED STEAM

GRAPHIC LOG — TEST No. 6

LOAD, — 3/4 — MARCH 28, 07

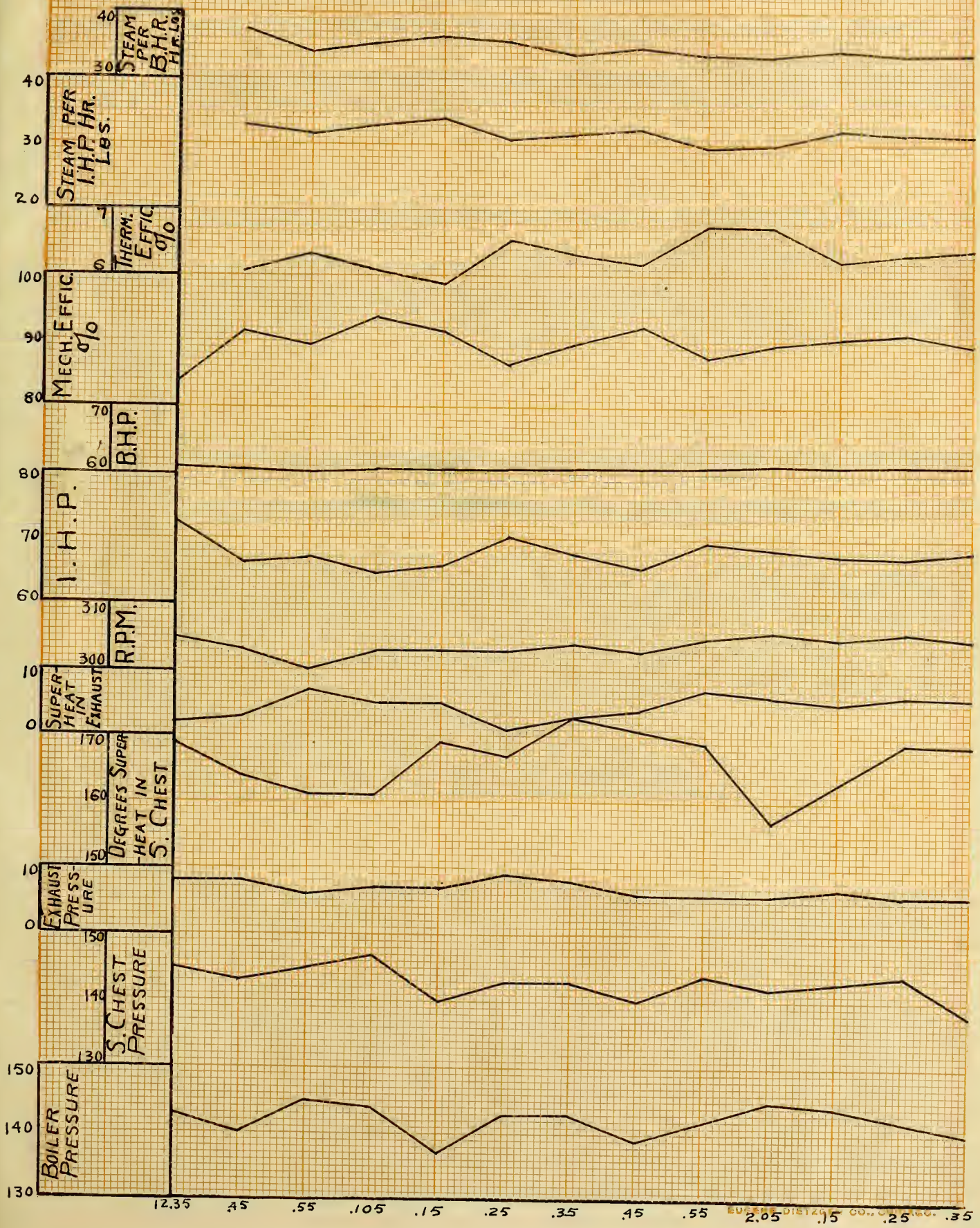
FRICKE & SLOANE



TEST OF IDEAL ENGINE, FOR SUPERHEATED STEAM
GRAPHIC LOG
LOAD,— FULL

TEST NO. 7
APRIL 26, '07

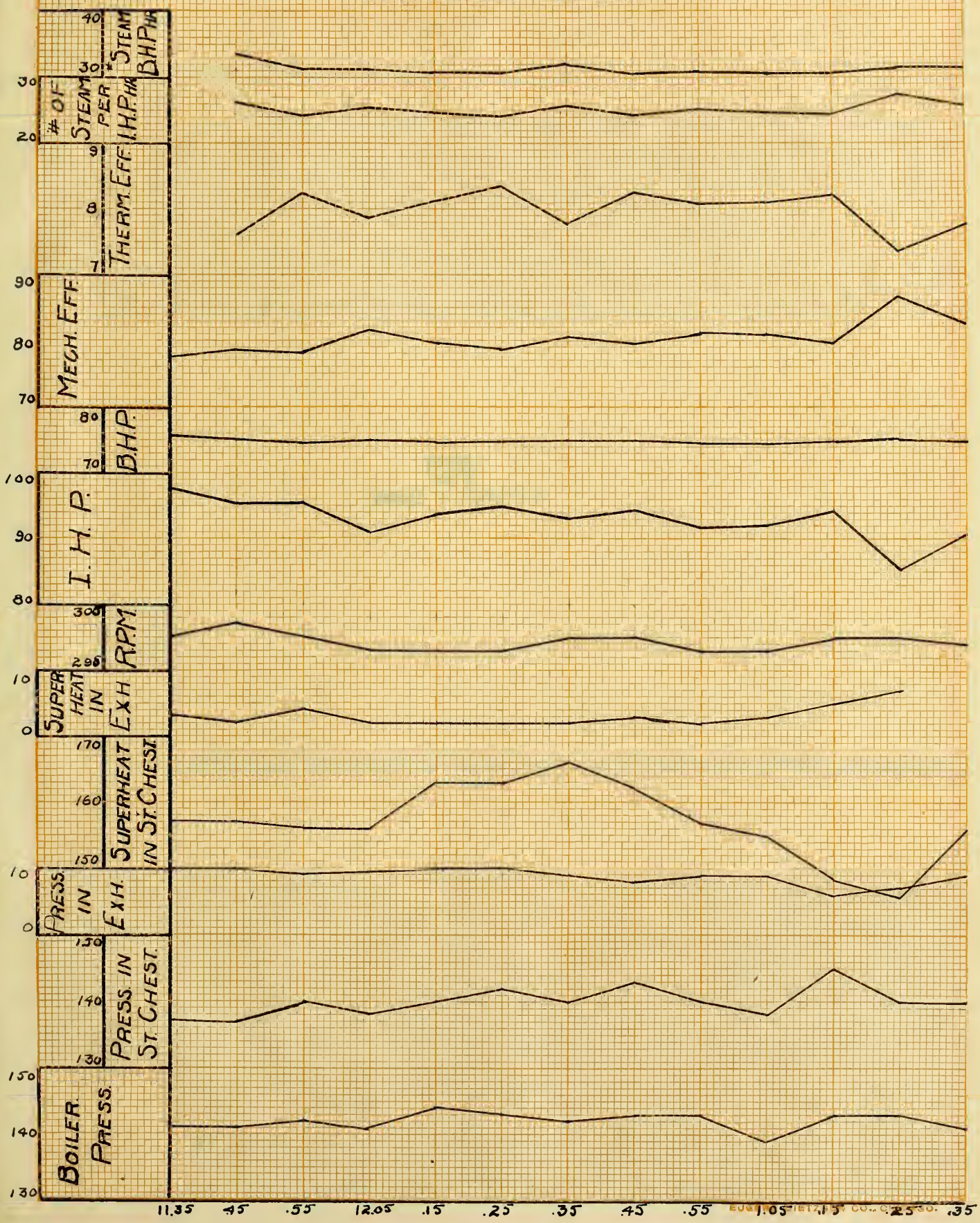
FRICKE & SLOANE.

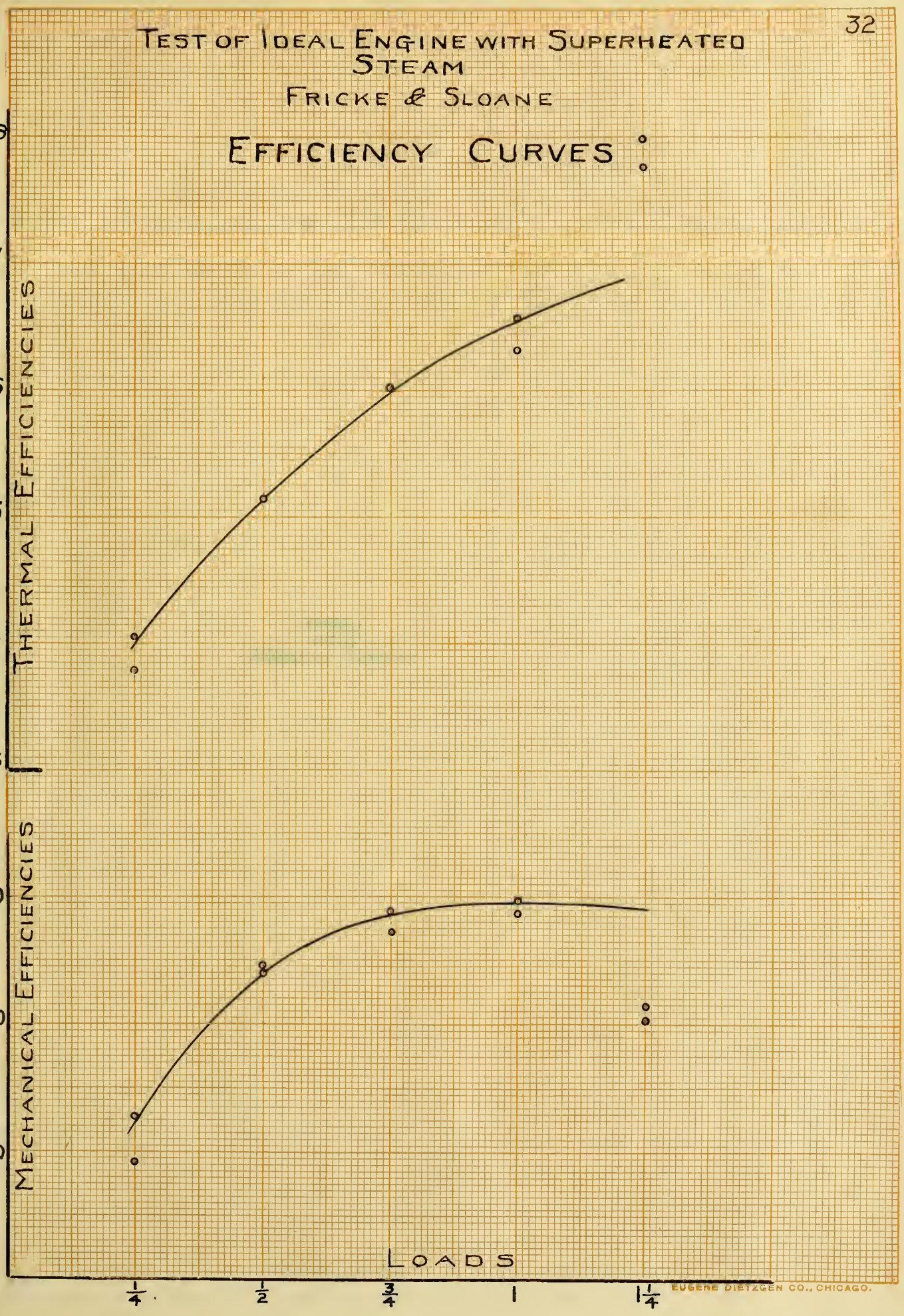


TEST OF IDEAL ENGINE WITH SUPERHEATED STEAM.
GRAPHIC LOG
LOAD, — 1/4

TEST NO. 10.
MAY 3, '07.

FRICKE AND SLOANE.

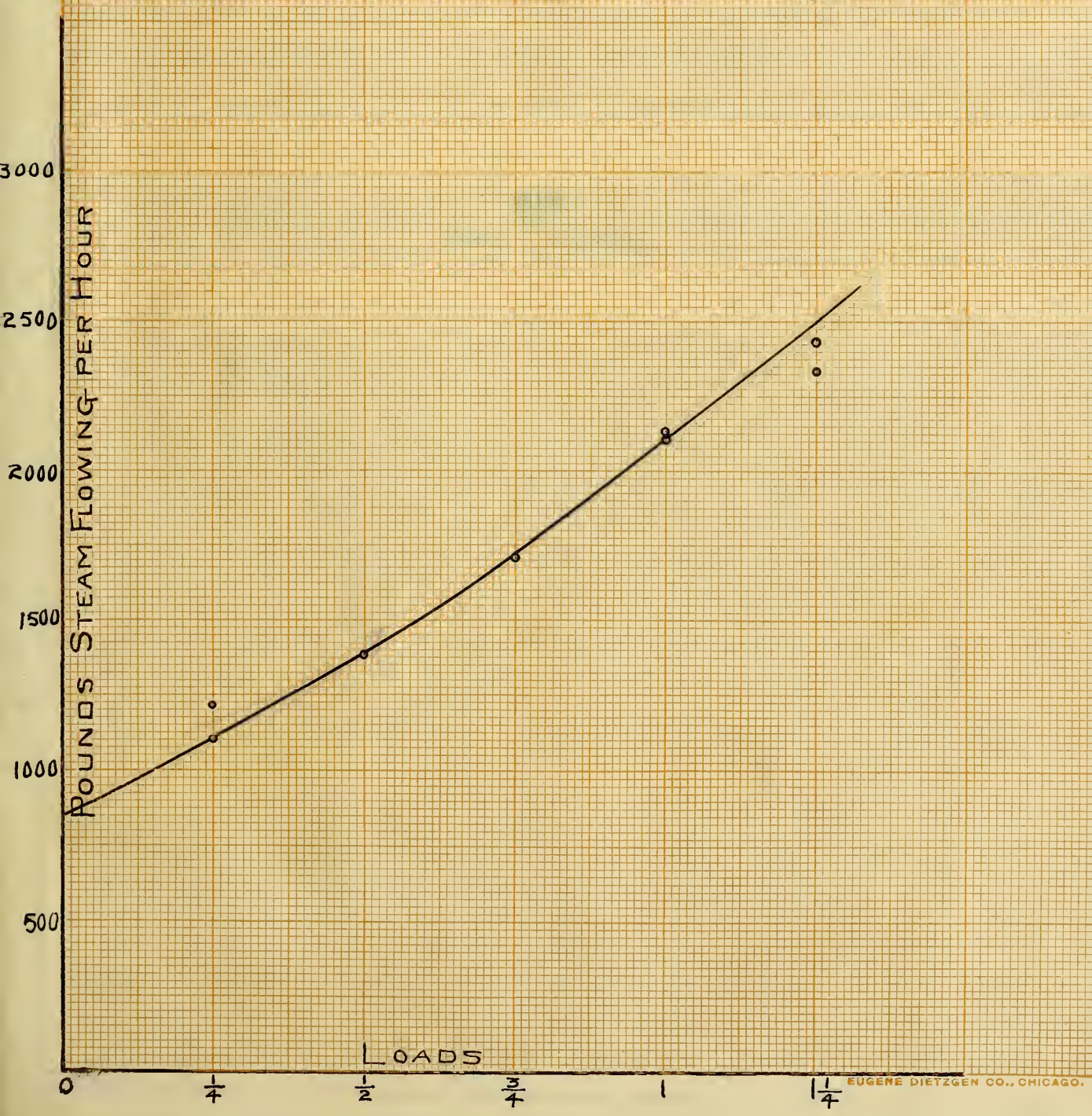



TEST OF IDEAL ENGINE WITH SUPERHEATED STEAM
FRICKE & SLOANE
EFFICIENCY CURVES
THERMAL EFFICIENCIES
8
7
6
5
4
3
MECHANICAL EFFICIENCIES
90
80
70
LOADS
1/4
1/2
3/4
1
1 1/4
EUGENE DIETZGEN CO., CHICAGO.

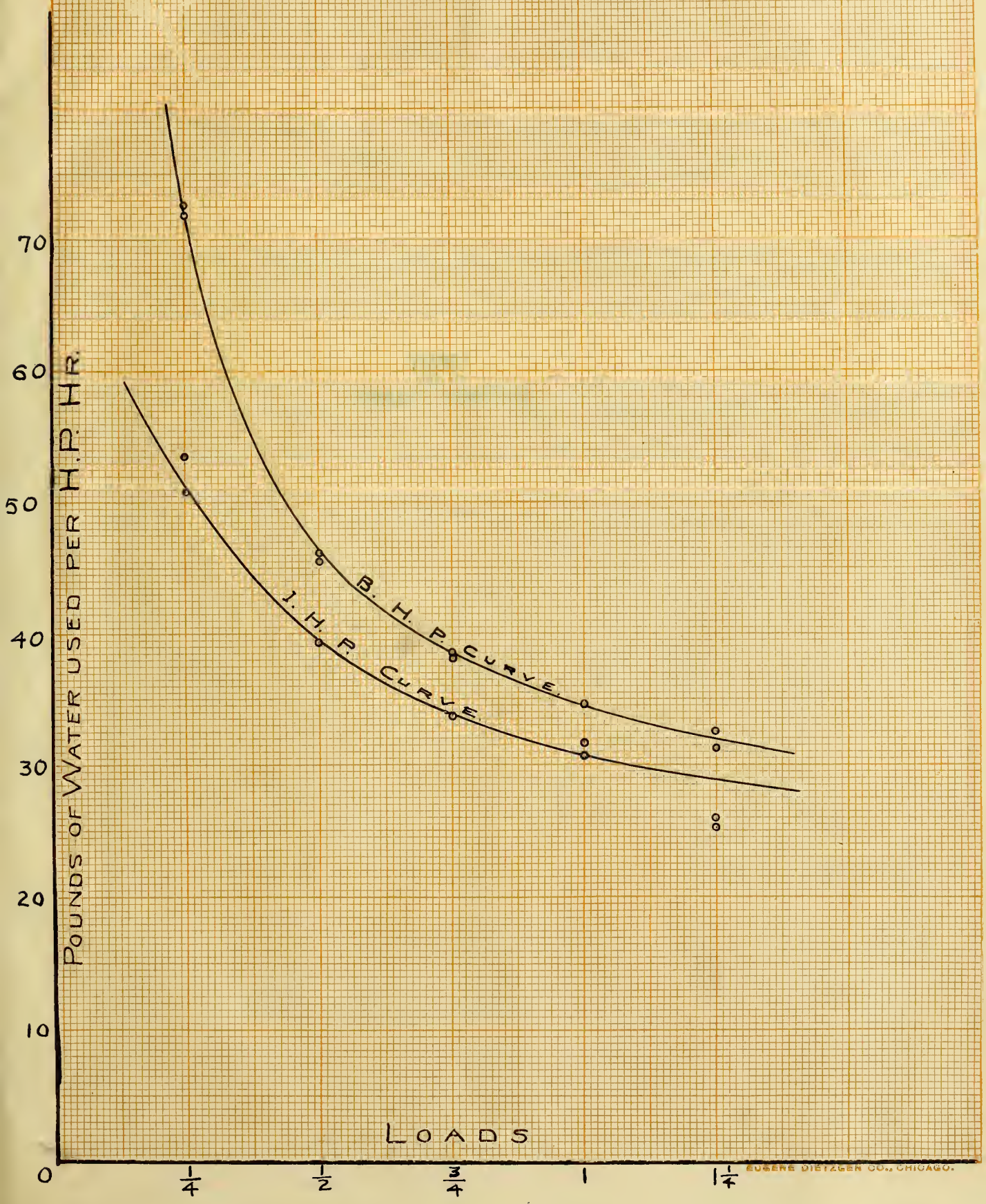
Test of Ideal Engine for Superheated Steam

Fricke & Sloane

Steam Flow Curve



Test of Ideal Engine with Superheated Steam
Fricke & Sloane
Water-Rate Curves



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